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Stock Assessments for British Columbia Herring in 1987 and Forecasts of the Potential Catch in 1988

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by

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ABSTRACT

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Herring stock abundance in British Columbia waters was assessed for 1987, and forecasts were made for 1988 using two analytical methods: (1) escapement model, and (2) age-structured model. Diving spawn survey data was utilized in the escapement model wherever available.

Forecasts of pre-fishery biomass are obtained by weighting the estimates from the two models. The forecasts, are for 79,680 tonnes to the northern and 86,210 tonnes to the southern stock assessment regions. These estimates represent a slight decrease from 1987 levels, reflecting below average recruitments to all the southern areas during the last spawning run.

The recommended 1988 catch (20% of the 1988 forecast herring run for stocks above CUTOFF levels) for the entire B.C. coast is 30,750 tonnes. All areas except the Queen Charlotte Islands should be available to the fishery in 1988.

Key words: Clupea harengus pallasi, Pacific herring, stock assessment, forecasts, age-structured analysis

RÉSUMÉ

Haist, V., J. F. Schweigert and D. Fournier. 1988. Stock assessments for British Columbia herring in 1987 and forecasts of the potential catch in 1988. Can. MS Rep. Fish. Aquat. Sci. 1990: 63 p.

L'abondance du stock de harengs dans les eaux de la Colombie-Britannique a été évaluée pour l'année 1987 et des prévisions ont été établies pour 1988 à l'aide de deux méthodes d'analyse: 1) un modèle d'échappée et 2) un modèle de structure par âge. Les données des relevés de la fraie par plongée ont été utilisées dans le modèle d'échappée lorsqu'elles étaient disponibles.

Des prévisions sur la biomasse antérieure à la pêche ont été obtenues en pondérant les estimations établies grâce aux deux modèles. Ces prévisions sont de 79 680 tonnes dans les régions du nord et du 86 210 tonnes dans les régions du sud. Ces estimations constituent une légère augmentation par rapport au niveau de 1987 et témoignent de recrutements inférieurs à la moyenne dans toutes les régions du sud au cours de la dernière fraie.

La prise recommandée pour 1988 (20% des prévisions de 1988 pour la remontée de harengs pour les stocks que se situent au-dessus des niveaux CUTOFF) pour toute la côte de la Colombie-Britannique est de 30 750 tonnes. Toutes les régions, sauf les Îles Reine-Charlotte, devraient être ouvertes à la pêche en 1988.

Mots clés: Clupea harengus pallasi, hareng du Pacifique, évaluation des stocks, prévisions, analyse en fonction de la structure par âge

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FOREWORD

This report was prepared by the Population Dynamics Program of the Herring Section (Biological Sciences Branch), and contains proposed catch levels for herring for the 1987/88 season. These recommended catches are based primarily on biological considerations, and may vary with those finally adopted by the PSARC Herring Sub-Committee. The final fishing plans adopted by Fisheries Management will be based not only on biological considerations, but also economic, social, enforcement, and other factors.

Results contained in this report were presented to the PSARC Herring Sub-Committee in September of 1987.

ACKNOWLEDGMENTS

This document represents not only the efforts of the Population Dynamics Program. Numerous other members of the departmental staff play key roles in the collection and processing of data. Herring ages were determined by Margaret Burke and Kathy Rutherford of the Pacific Biological Station Ageing Unit. Lorena Rosenfeld processed the catch, sample, and spawn data and maintained the pertinent data bases. Also, Fisheries Branch personnel and contractors contribute to the sampling effort.

1. INTRODUCTION

1.1 GENERAL

Forecasting the potential catch that can be removed from herring stocks requires an assessment of the present stock status and the determination of factors which affect stock dynamics, in particular, recruitment. Traditionally, equilibrium based methods such as yield models have been favoured. They assume constancy in age structure, growth, and mortality. However, herring are strongly affected by changes in environmental conditions thus making equilibrium models unattractive. The methods we use estimate current stock conditions on the basis of which potential catches are recommended. Catch levels have been formulated to ensure conservation of the stocks.

In this report we present two methods to assess present herring stock status: 1) an escapement model (Schweigert and Stocker 1988); and 2) an age-structured model (Fournier and Archibald 1982). Both methods use a 37-year time series of catch and spawn deposition information and age structure and size-at-age data obtained from biological samples.

1.2 DATA BASE

The primary data sources for the stock assessments are spawn survey data, commercial catch landing data, and age composition data from biological samples of commercial fishery, pre-fishery charter, and research catches. These data are available on computer files for the period 1950 to 1987. This time span includes the reduction fishery period to 1968 and the subsequent roe fishery period starting in the early 1970s.

Of the three data sets, the spawn data contain the largest measurement errors. We feel that the quality of spawn surveys has improved greatly over the 37-year span of these observations. This improvement is a result of increased numbers of people and vessels being involved in spawn surveys, increased attention to data measurements, increased coverage of subtidal spawnings, and increased research on estimating egg deposition from spawn observations. The consistent observations made during the 37 years of spawn surveys are the length, the width, and a measure of intensity of spawnings. The escapement model estimates absolute egg numbers from these observations and includes a width conversion to adjust for the inability to survey subtidal spawns adequately. In recent years some spawns have been surveyed using SCUBA methods. We assume these surveys provide reasonably accurate estimates of spawn width and egg density and these data have been used in the escapement model where available. The age-structured model uses a spawn index which sums lengths multiplied by standardized widths and intensities.

Catch information was obtained from landing slip data. Both models use the landing slip data summed by season (seasons run from July 1 to June 30). The 1986/87 catch figures are based on hailed estimates because sales slip data were not available for timely analysis. The sales slips record catch in tonnes. Numbers of fish in the catch were calculated using the average fish weight from catch samples for the season.

Age structure data are used in both models. The information from catch samples are used for years when there were commercial fisheries. For years with no fisheries, or when catch samples do not appear to be representative, pre-fishery and research samples are also used. Additional data used in the age-structured model are age specific fecundities and average weights at age.

1.3 STOCK CONSIDERATIONS

We continue to use the stock concept introduced for the 1985 assessment (Haist et al. 1986) with minor modifications this year (Figs 1.1 and 1.2). In the Queen Charlotte Islands, herring spawning in the area from Skincuttle Inlet and Selwyn Inlet are treated as one stock. The stock concept for the Prince Rupert District remains unchanged encompassing Statistical Areas 3 to 5. The revised central coast stock concept separates the migratory stocks from the local stocks. The migratory component used in the current analysis includes all of Statistical Area 7 plus Kitasu Bay in Area 6 and Kwakshua Channel in Area 8. The Strait of Georgia is separated into two stock groupings. The northern area includes all of Statistical Areas 14 to 16, Area 17N and Deepwater Bay and Okisollo Channel in Area 13. The southern stock comprises Areas 17S, 18 and 19. The two stock groupings used for the west coast of Vancouver Island are southern (Areas 23 and 24) and northern (Areas 25 to 27).

Additionally, biomass estimates from the escapement model are presented for minor and resident stocks. The level of geographic aggregation used for these estimates is the section (Haist and Rosenfeld 1988).

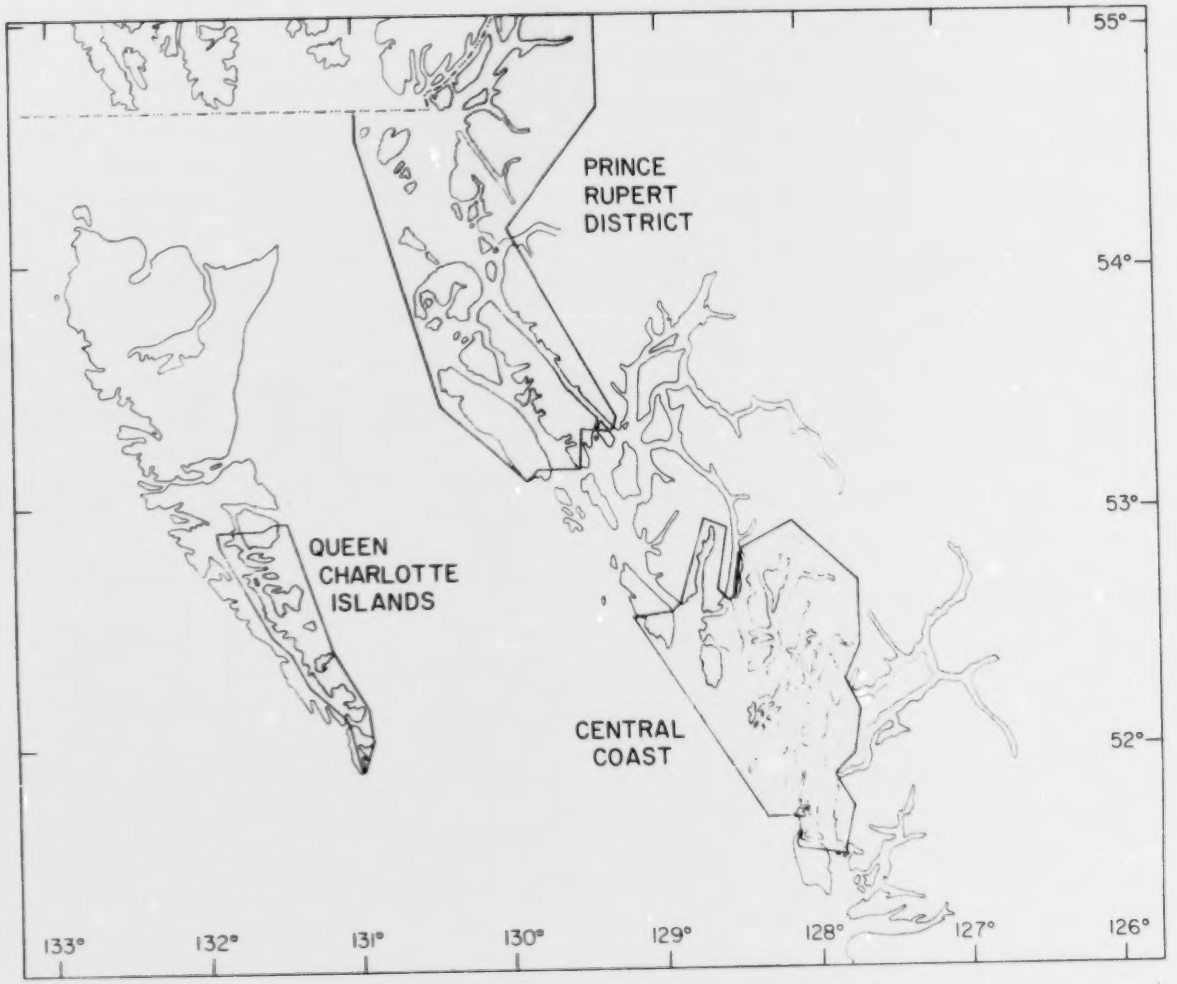

Fig. 1.1. Herring stock assessment regions in northern B.C.

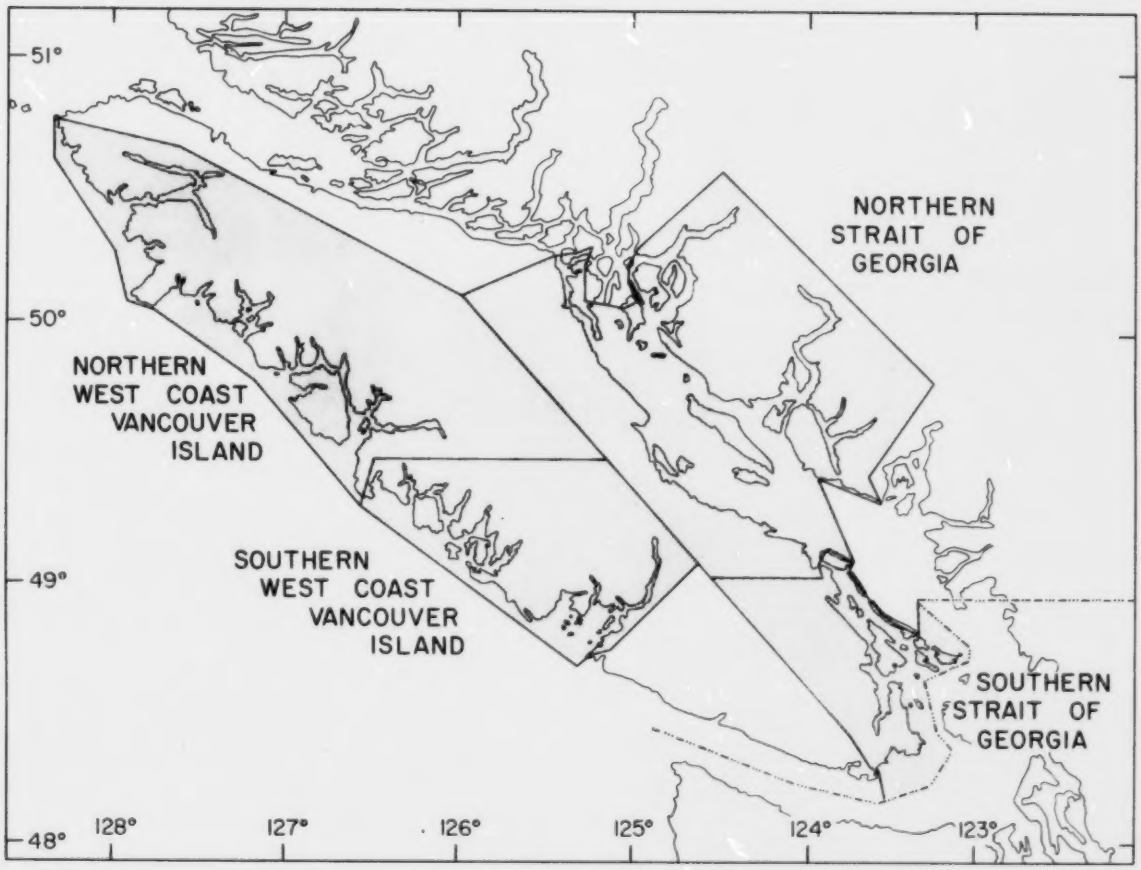

Fig. 1.2. Herring stock assessment regions in southern B.C.

2. ESCAPEMENT MODEL

The escapement model was developed for the 1984 assessments (Haist et al. 1985; Schweigert and Stocker 1988). Subsequently, it has been modified to incorporate age structure information which allows separation of the growth and recruitment components of stock productivity. This also facilitates comparison of estimates with those from the age-structured model. As in past years, when diver spawn survey information is available it is used in preference to surface survey data. In 1987, fishery officers conducted visual dive surveys of the major herring spawns on the south coast. Additionally, in the Queen Charlotte Islands, Pacific Biological Station personnel completed a detailed dive survey of all spawnings. Where dive survey data are not available surface survey data is adjusted as described below. In this year's assessment estimates are again presented for the 7 major stock assessment regions which contain distinct migratory stocks. Stock estimates are also presented for all sections which are not included in the major stock assessment regions. These minor or resident stocks may be capable of supporting very small fisheries, impoundments, or spawn-on-kelp operations.

2.1 METHODS

In the escapement model, estimates of the potential catch in each stock assessment region are calculated as 20 percent of the forecast run size. The forecast run size is the product of the estimated escapement in the previous year and an average annual survival rate (0.64) plus an estimate of anticipated recruitment to each stock. Recruitment is estimated as poor, average, and good by calculating the means of the third poorest, the middle third, and the third best recruitments observed during the historical time series of recruitment estimates from 1951-1987. The estimates of total catch (tonnes) and spawning escapement (billions of eggs) are converted to fish at age based on the sampling data for each area. For each area the age structure and average weight at each age are calculated from all samples available for that region. In some years, no data is available from a region and information from an adjacent area is utilized in the analysis. Estimates of repeat spawners and recruiting fish are converted back to tonnages using average weights at age for the current year. Estimates of spawning biomass in 1987 and forecasts for 1988 are presented for the seven stock assessment regions.

The estimated escapements for each region are derived from information on spawn deposition. Dive survey observations are used directly while surface survey observations are adjusted to render them comparable to dive estimates based on calibration equations derived from duplicate surveys. The calibration equations utilized for the 1987 assessments and 1988 forecasts differ slightly from those used in the previous year (Haist et al. 1987). This year we have incorporated new data derived from the detailed dive survey conducted in the Queen Charlotte Islands during 1987 (Haegele and Schweigert 1987).

The equation used to adjust surface survey spawn width estimates to diver width estimates is:

$$\text{Adjusted width} = 74.727 + 0.816 \bullet \text{Surface survey width}$$

This equation is virtually identical to that used in last year's assessment. The regression equation used to estimate the average density of eggs for each spawn from the estimate of average egg layers is:

$$\text{Eggs/m}^2 = 183.252 + 76.738 \bullet \text{Average surface layers} \bullet 1000.$$

This relationship differs from the exponential equation used last year but provides the best fit to the data. Other forms of relationship were examined and all provided similar estimates of total spawning biomass.

Surface survey data are adjusted using the foregoing equations in all areas except for Johnstone Strait (Statistical Areas 9-13). In this area no adjustment is applied to the spawn widths as previous dive surveys in the area (Schweigert and Haegele 1988a, b) indicated that widths were accurately assessed from the surface. Egg deposition is estimated from the product of total spawn length, adjusted width, and egg density as estimated from the average surface layer estimate. The total egg deposition is converted to tonnes of spawners based on the average estimate of 100 eggs per gram of spawning fish. Escapement plus catch provides an estimate of the total pre-fishery spawning stock biomass.

Estimates of egg deposition from the diver survey are based on a two-stage sampling design (Schweigert et al. 1985). Spawn lengths and widths are determined by exploratory raking, snorkelling, or by swimming along transects. Egg density for each spawn is estimated from the mean of a series of quadrats located along the transects. For each quadrat observations are made on several variables: dominant vegetation type, proportion of the quadrat covered by vegetation, number of layers of eggs on vegetation, proportion of the bottom substrate covered by eggs, and an estimate of the number of egg layers on bottom substrate. For the vegetation, egg density is estimated from the following equation:

$$\text{Eggs/m}^2 = 868.2080 \bullet L^{0.7812} \bullet P^{1.5599} \bullet V_i \bullet Q_j \bullet 1000.$$

where L = number of layers of eggs on the dominant vegation type
P = proportion of quadrat covered by vegetation
V_1 = 1.1742 parameter for sea grasses
V_2 = 0.8651 parameter for rockweed
V_3 = 0.8385 parameter for flat kelp
V_4 = 0.9566 parameter for other brown algae
V_5 = 0.9284 parameter for leafy red and green algae
V_6 = 1.000 parameter for stringy red algae
Q_1 = 0.9071 parameter for 1.00 m^2 quadrats
Q_2 = 0.6050 parameter for 0.50 m^2 quadrats
Q_3 = 1.000 parameter for 0.25 m^2 quadrats

Eggs on rock are estimated from the product of proportion of the quadrat covered by eggs, number of egg layers, times 340,000 egg/m^2 (Haegele et al. 1979). Total egg density for each quadrat is the sum of eggs on vegetation plus eggs on rock.

2.2 RESULTS

The 1988 forecast spawning run to the lower east coast of the Queen Charlotte Islands is 11,000 tonnes assuming average recruitment (Table 2.6). This stock has been declining since 1981 when the very strong 1977 year-class became fully recruited to the stock (Fig. 2.1). Poor recruitments to this area in the intervening years have accentuated the stock decline. Another poor recruitment to this stock would yield a spawning run of about 9,400 tonnes while a very good recruitment could produce a run of 19,000 tonnes of spawners. The intensive diving survey of this area yielded a 1987 spawning biomass estimate of 13,963 tonnes which was an increase from the previous year. However, the 1986 spawn survey was felt to be incomplete due to poor weather which hampered efforts to survey the spawn. In addition, about 25% of the spawn in this area occurs on Macrocystis sp. which cannot be surveyed accurately using the traditional surface survey. The dive survey of the area in 1987 probably found more spawn than would have been observed with a surface survey. Nevertheless, the spawning biomass forecast with even an average recruitment is below the CUTOFF level for this area, indicating that conservation measures are needed to rebuild this stock.

The forecast runs for the Prince Rupert District with average and good recruitments are for 31,800 and 41,700 tonnes, respectively (Table 2.6). This stock is now at or near historically high levels and has maintained itself at this level for the past few years. The 1987 spawning biomass estimate of 38,586 tonnes is the highest observed over the time period of our analysis, 1951-1987 (Table 2.1, Fig. 2.1).

Forecast run sizes for the Central Coast are for 24,700 tonnes with average or 21,100 tonnes with poor recruitment. This stock has remained at levels of 30-40,000 tonnes since 1980 and appears to be in relatively good condition (Fig. 2.1). The spawning biomass estimate for 1987 of 28,123 tonnes is up slightly from the previous two years, suggesting that similar to higher levels may be anticipated in 1988 (Table 2.1, 2.6).

The forecast run sizes for south coast stocks continue to surpass the levels of the early 1980s. The northern Strait of Georgia forecast run is for 31,400 and 43,600 tonnes with average and good recruitment, respectively (Table 2.6). The forecast with average recruitment indicates a level similar to that of 1987 but down substantially from 1986 when the strong 1983 year-class recruited to the stock (Table 2.2, Fig. 2.2). Spawning biomass in 1987 was 26,432 tonnes, down substantially from the 55,447 tonnes in 1986. The southern Strait of Georgia stock forecast with average recruitment is 9700 tonnes and with good recruitment 12,500 tonnes. The downward trend in this

stock has slowed with the appearance of the good 1983 year-class. The spawning biomass of 8783 tonnes in 1987 is up slightly from 1986 levels (Table 2.2, Fig. 2.2) but down from the 20,000 tonne level observed in 1979 (Table 2.2).

The stocks on the southern west coast of Vancouver Island are forecast at 23,400 and 32,600 tonnes of spawners with average and good recruitment, respectively (Table 2.6). The stock levels appear to be approaching the long term average but they are down from 1985 and 1986 biomasses when the good 1981 and 1982 year-classes were prominent (Table 2.2, Fig. 2.2). Even poor recruitment should result in 19,000 tonnes of spawners in the area, a level well above the CUTOFF of 15,400 tonnes recommended for this area. Stock biomass levels forecast for the northern west coast of Vancouver Island are 12,300 and 21,800 tonnes with average and good recruitment. This stock is now only slightly below historical average levels, having recovered from the low levels of 1983 and 1984 (Table 2.2). Poor recruitment could result in about 9200 tonnes of spawners returning to the area, again well above the cutoff level of 6000 tonnes required for this stock.

The minor and resident stock abundance estimates are presented in Tables 2.3 to 2.5. There are problems in assessing the stocks in many of the more remote locations due to inadequate spawn survey coverage and a general absence of age composition data, so absolute estimates of abundance are probably not very accurate. However, the abundance trends generally follow those of the nearby migratory stocks. No areas which could support substantial fisheries are in evidence. The stocks in Area 2W are stable but lower than historical levels. The minor stocks in the Central Coast assessment region are also not surveyed with sufficient regularity to discern possible trends, but no major fishable biomasses are apparent. The Johnstone Strait stocks are in many instances below the long term average, reflecting perhaps irregular and incomplete spawn survey coverage of some of the areas in this region.

Table 2.1. Estimates of spawner biomass, catch, and total stock abundance (tonnes) for the Northern stock assessment regions for 1951-1987.

	Queen Charlotte Is.			North Coast			Central Coast		
Season	Spawners	Catch	Stock	Spawners	Catch	Stock	Spawners	Catch	Stock
50/51	4299	2847	7146	29183	45865	75049	21477	41898	63376
51/52	3122	10147	13269	10361	52379	62740	10609	32526	43134
52/53	5764	0	5764	14599	1865	16464	20751	768	21519
53/54	11684	1786	13470	10197	27277	37473	16925	24164	41089
54/55	5936	1234	7171	12997	17806	30802	16086	11542	27628
55/56	5556	77589	83144	12822	10182	23004	11284	43455	54739
56/57	1513	23247	24760	19895	28035	47929	6069	23261	29329
57/58	790	11166	11956	8666	4523	13189	8250	9849	18100
58/59	7112	7027	14139	16747	10224	26971	7029	27870	34899
59/60	3558	0	3558	13414	18476	31890	20970	3631	24601
60/61	6568	653	7222	14626	42746	57372	8545	21564	30109
61/62	4394	7632	12026	20475	27660	48135	22973	8910	31883
62/63	4549	14980	19529	15419	40228	55647	10690	35823	46512
63/64	3248	26962	30210	16698	30340	47037	11934	30019	41954
64/65	1472	32423	33895	6298	44211	50508	4528	15436	19964
65/66	3551	2746	6297	5857	17295	23152	5010	35530	40540
66/67	771	161	932	3051	7998	11049	8451	21083	29534
67/68	734	80	814	6420	2144	8563	8896	1459	10354
68/69	1865	0	1865	915	547	1462	3654	100	3754
69/70	2887	0	2887	11839	1498	13337	19770	209	19979
70/71	4592	0	4592	9737	3500	13237	6496	3614	10110
71/72	2897	1260	4157	10917	4494	15411	8511	8131	16642
72/73	2424	2231	4654	11252	1607	12859	23974	7777	31751
73/74	6980	2277	9257	8821	3819	12640	19533	8773	28306
74/75	3972	4408	8380	10625	1702	12326	18661	8722	27382
75/76	9214	9425	18638	16009	4307	20316	29962	12068	42030
76/77	11245	10024	21270	15358	8142	23500	27218	11106	38324
77/78	10059	9489	19547	7375	8588	15962	16747	14046	30793
78/79	7677	7953	15630	13803	4317	18120	14263	5	14268
79/80	24553	2274	26828	16985	3425	20411	30658	538	31196
80/81	23834	5631	29465	17181	3090	20271	32915	2573	35488
81/82	19373	3778	23151	14926	1984	16910	34139	6370	40509
82/83	16979	5597	22576	26146	0	26146	41710	5640	47350
83/84	20176	4719	24894	27921	3761	31681	28162	7193	35355
84/85	15624	6109	21733	32690	6747	39437	24266	5209	29475
85/86	5846	4536	10382	35353	8418	43771	23460	5179	28639
86/87	13963	1720	15683	38586	5552	44138	28123	3231	31354

Table 2.2. Estimates of spawner biomass, catch, and total stock abundance (tonnes) for the Southern stock assessment regions for 1951-1987.

	Georgia Strait - N			Georgia Strait - S			WCVI - South			WCVI - North		
Season	Spawners	Catch	Stock	Spawners	Catch	Stock	Spawners	Catch	Stock	Spawners	Catch	Stock
50/51	31889	17787	49677	3633	26011	29644	6464	15914	22378	13135	6117	19252
51/52	28828	17635	46462	14392	28211	42603	6492	10630	17122	3303	16415	19719
52/53	34728	4376	39104	53093	4037	57130	8997	20	9017	25713	0	25713
53/54	23762	20258	44020	36987	45207	82194	5279	28699	33978	11125	8875	20000
54/55	30819	26818	57637	31712	41823	73535	6384	6041	12425	10438	6524	16962
55/56	13987	27273	41260	14844	44789	59633	8910	17098	26008	13015	508	13523
56/57	12925	21374	34299	6992	38235	45227	6344	2600	8944	18939	491	19430
57/58	8149	9012	17160	17385	11616	29001	11551	513	12063	7282	43	7325
58/59	16148	34189	50337	16285	15836	32121	6049	37385	43434	5632	32370	38002
59/60	20530	21949	42479	9457	45497	54954	5577	17652	23229	3717	38145	41861
60/61	16956	15675	32631	9247	30430	39678	7968	13489	21457	5531	17356	22887
61/62	16624	30356	46980	5558	34945	40503	9076	15597	24673	14794	12777	27571
62/63	16646	33746	50392	8725	35101	43826	8764	4019	12783	4289	17230	21520
63/64	15482	36798	52280	6689	40179	46868	17749	20230	37978	8537	1914	10450
64/65	13602	27234	40836	2505	19888	22393	7052	14063	21115	8980	4741	13721
65/66	4792	20965	25758	2723	12337	15059	3346	8169	11516	2861	4207	7068
66/67	6715	11136	17851	2504	19885	22389	2100	9171	11271	4655	6260	10915
67/68	7026	949	7975	5247	981	6227	4073	0	4073	3628	0	3628
68/69	9246	314	9560	7377	420	7797	5530	0	5530	9256	0	9256
69/70	22791	519	23311	12793	365	13157	17157	0	17157	8344	0	8344
70/71	27787	946	28733	10764	745	11509	17946	0	17946	8496	0	8496
71/72	14022	5814	19835	8946	2368	11315	17549	4285	21835	13100	2609	15709
72/73	15192	6585	21777	9647	970	10617	6167	10409	16576	10983	7894	18877
73/74	28003	3211	31214	15660	791	16451	13408	6371	19780	5549	10489	16038
74/75	35638	5114	40752	16951	1063	18014	21043	18593	39636	11512	7515	19027
75/76	39198	8163	47361	9453	4075	13528	28724	33441	62165	5363	5520	10883
76/77	47444	11304	58747	5988	6205	12193	29326	26453	55779	7312	3688	11000
77/78	53734	13874	67608	13558	10129	23686	18687	18050	36737	16769	4846	21615
78/79	73842	8638	82480	19318	11699	31018	28795	9876	38671	36820	9510	46330
79/80	54920	4524	59444	11720	1294	13014	27500	2276	29776	32089	2226	34315
80/81	32161	7375	39536	12197	4645	16842	24790	4928	29718	13033	3833	16866
81/82	63276	5705	68981	8024	7086	15110	11142	3110	14252	14294	2947	17242
82/83	32037	16220	48257	11613	949	12562	11094	6141	17234	12332	2597	14930
83/84	15645	9869	25515	11947	1175	13122	16115	5718	21833	6394	1032	7426
84/85	21142	6228	27370	7644	791	8435	26016	178	26194	3837	0	3837
85/86	55447	281	55729	7776	307	8083	33326	204	33530	16000	0	16000
86/87	26558	5304	31862	8783	3831	13614	23103	13106	36209	10993	2448	13441

Table 2.3. Estimates of the total biomass and average reduction and roe catches (tonnes) for minor and resident stocks in the Queen Charlotte Islands for 1951-1987.

Season	Section 001	002	003	004	005	006	Total Area 2W	Section 022	023
50/51	0	0	0	0	0	0	0	848	0
51/52	0	0	0	0	0	0	0	492	0
52/53	0	0	790	163	0	0	953	1976	0
53/54	0	0	0	0	0	0	0	25360	0
54/55	0	0	0	0	0	0	0	19017	0
55/56	0	0	0	0	0	0	0	5895	93
56/57	0	0	147	0	0	464	611	1195	0
57/58	0	0	221	0	40	0	261	87	0
58/59	1672	1164	1614	0	1024	1078	6552	11196	0
59/60	92	667	1411	0	116	3738	6024	3627	0
60/61	1127	410	520	0	379	2094	4530	4320	0
61/62	403	1962	1620	0	301	970	5256	8031	0
62/63	0	2407	0	0	0	0	2407	3034	0
63/64	430	1375	772	187	164	3595	6523	3653	0
64/65	285	0	308	103	1486	3455	5637	5951	0
65/66	0	62	24	0	21	0	107	3713	0
66/67	80	1203	0	0	157	66	1506	777	184
67/68	0	6	107	0	75	85	273	256	0
68/69	24	280	327	0	949	0	1580	1107	0
69/70	0	417	363	0	807	412	1999	1222	5109
70/71	0	159	805	0	580	1833	3377	2069	6727
71/72	0	452	476	0	2022	3375	6325	3573	7577
72/73	0	130	1505	0	2334	5380	9349	1151	9421
73/74	0	0	1388	0	3016	4014	8418	1632	6277
74/75	0	306	1401	253	1567	5768	9295	2239	5318
75/76	0	405	491	0	1855	9197	11948	3028	5079
76/77	0	283	647	207	2484	5379	9000	3097	4205
77/78	651	0	2071	0	2200	3579	8501	3994	3559
78/79	1293	50	682	102	873	987	3987	1642	3624
79/80	1151	1384	1864	0	2375	2870	9644	31	0
80/81	1193	3954	2089	406	1204	1174	10020	695	2076
81/82	0	6174	3542	437	4124	2258	16535	877	544
82/83	254	3491	4268	543	5288	1362	15206	581	1756
83/84	591	2648	1115	0	2167	735	7256	2295	1765
84/85	0	2176	882	36	1947	1093	6134	407	1212
85/86	0	1109	298	0	1413	0	2820	2609	920
86/87	0	2040	0	0	730	564	3334	810	1717
Avg Biomass	280	1052	962	74	1264	1986	5617	4015	2035
Avg Catch (1951-67)	35	0	6	0	57	322	420	5193	5
Avg Catch (1972-87)	0	12	143	0	316	665	1136	177	956

Table 2.4. Estimates of the total biomass and average reduction and roe catches (tonnes) for minor and resident stocks in the Central Coast and northern Johnstone Strait for 1951-1987.

	Section										Area	Area	
Season	061	062	063	064	065	066	081	082	083	084	9	10	Total
50/51	0	0	12	116	0	3180	0	9	0	560	762	191	4830
51/52	0	0	0	104	211	0	2374	10	0	669	557	70	3995
52/53	0	0	0	0	0	0	0	0	0	0	200	675	875
53/54	0	181	0	810	223	59	309	994	0	453	2170	489	5688
54/55	0	367	95	2923	2118	113	709	274	279	406	5334	1401	14019
55/56	0	271	48	16	62	8	0	307	18	879	164	153	1926
56/57	4906	149	22	54	1983	0	1505	766	0	0	3077	2158	14620
57/58	1890	295	18	1	324	0	0	1753	0	0	642	470	5393
58/59	1748	233	694	58	67	366	75	1134	0	334	2870	1232	8811
59/60	19	615	2523	250	1644	0	0	330	26	406	405	586	6804
60/61	0	672	680	11	3666	0	289	457	0	10140	1037	911	17863
61/62	152	2298	90	0	5055	138	6478	24	0	6799	5827	1495	28356
62/63	377	2506	1282	181	65	0	2345	1169	0	8728	4105	536	21294
63/64	633	1578	2117	0	934	31	1509	953	529	2045	8282	1171	19782
64/65	1812	1237	137	0	656	40	353	673	169	233	1603	377	7290
65/66	4209	1966	599	277	37	147	3251	822	819	1952	5664	1326	21069
66/67	3045	1760	130	117	191	0	270	270	1176	807	3166	2488	13420
67/68	1511	59	52	1	0	0	0	913	51	289	409	1490	4775
68/69	0	0	6	34	0	0	282	16	0	307	115	46	806
69/70	0	0	71	62	14	27	672	272	8	0	1603	335	3064
70/71	0	0	44	15	29	0	264	493	211	1635	623	819	4133
71/72	0	0	14	0	0	444	169	429	258	1148	1031	1164	4657
72/73	0	79	43	0	0	0	147	137	1217	151	3804	138	5716
73/74	0	40	37	0	0	0	62	129	641	240	1050	300	2499
74/75	0	0	39	0	5	0	368	126	1152	336	884	299	3209
75/76	0	193	0	0	30	0	115	141	922	131	732	180	2444
76/77	0	0	30	0	2	0	0	134	499	827	657	59	2208
77/78	57	0	4	0	0	0	37	64	249	0	419	212	1042
78/79	0	208	0	0	0	168	0	41	223	0	118	80	838
79/80	0	0	0	0	0	573	0	141	0	0	302	241	1257
80/81	189	27	0	0	0	0	0	75	111	163	71	191	827
81/82	482	0	0	0	0	0	0	38	0	0	964	754	2238
82/83	0	119	0	0	0	0	0	15	133	185	228	591	1271
83/84	0	0	0	0	0	0	0	35	287	0	54	704	1080
84/85	10	269	0	0	0	0	0	0	87	0	144	222	732
85/86	0	828	0	0	0	0	0	100	53	0	1989	601	3571
86/87	387	205	0	0	0	609	0	213	182	794	1451	78	3919
Average Biomass	649	490	266	152	525	179	654	408	282	1231	1894	734	7464
Av Catch (1951-67)	1105	829	471	264	1013	144	1144	576	130	1913	2475	749	0
Av Catch (1972-87)	16	0	0	0	0	0	0	0	132	90	223	96	0

Table 2.5. Estimates of total biomass and average reduction and roe catches (tonnes) for minor and resident stocks in southern Johnstone Strait for 1951-1987.

Season	Area 11	Section 126	Section 127	Other Area 12	Other Area 13	Total
50/51	1	986	339	3236	128	4690
51/52	5	2292	347	5632	88	8364
52/53	0	214	264	1365	181	2024
53/54	2	871	415	5102	408	6798
54/55	6515	323	1083	1138	374	9433
55/56	257	565	198	313	592	1925
56/57	13	638	129	12723	83	13586
57/58	15	29	183	4323	0	4550
58/59	145	3436	1093	1624	380	6678
59/60	675	979	2516	5543	1909	11622
60/61	272	819	282	1656	810	3839
61/62	780	112	749	9853	419	11913
62/63	2187	591	1039	5869	772	10458
63/64	82	448	5706	9385	1823	17444
64/65	1271	996	2940	12270	4075	21552
65/66	1171	297	2108	14309	708	18593
66/67	253	139	997	13408	3300	18097
67/68	8	51	156	4492	5	4712
68/69	21	198	187	1477	235	2118
69/70	48	303	239	2742	186	3518
70/71	71	154	91	1867	511	2694
71/72	31	1502	1163	4172	1476	8344
72/73	11	1143	3651	8864	373	14042
73/74	7	569	3640	1765	314	6295
74/75	28	1170	3358	1867	921	7344
75/76	33	1229	2042	822	266	4392
76/77	15	415	1696	1157	186	3469
77/78	16	570	574	250	253	1663
78/79	60	61	67	175	350	713
79/80	14	246	395	831	417	1903
80/81	9	184	278	486	1412	2369
81/82	0	138	549	67	2750	3504
82/83	17	93	241	101	3381	3833
83/84	9	163	477	644	2	1295
84/85	0	476	1068	126	239	1909
85/86	37	162	194	488	46	927
86/87	12	144	167	473	322	1118
Avg Biomass	427	688	1231	4261	900	7507
Avg Catch (1951-67)	35	0	6	0	57	322
Avg Catch (1972-87)	0	12	143	0	316	665

Table 2.6. Estimates of 1987 spawning biomass and forecasts of age 4+ and recruit biomass in 1988 (in thousands of tonnes) from escapement model analysis.

Stock Assessment Region	1987 Spawning Biomass	1987 Forecasts			
		Age 4+	Age 3 recruits		
			Poor	Average	Good
Queen Charlotte Islands	13.8	8.8	0.6	2.2	10.2
Prince Rupert District	38.3	27.6	1.2	4.2	14.1
Central Coast	27.5	18.5	2.6	6.2	17.4
Strait of Georgia					
Northern stock	25.0	18.9	6.3	12.5	24.7
Southern stock	6.6	5.5	2.7	4.2	7.0
West Coast of Vancouver Is.					
Northern stock	20.2	15.7	3.3	7.7	16.9
Southern stock	9.8	7.4	1.8	4.9	14.4

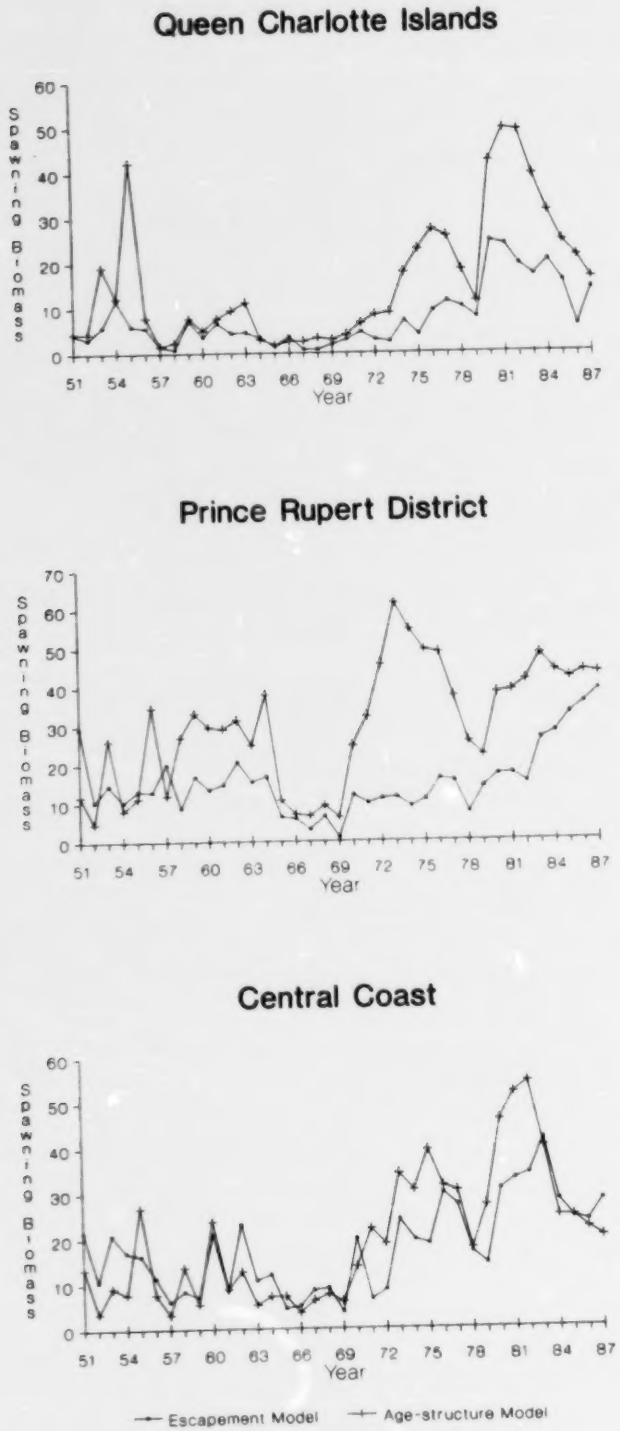

Fig. 2.1. Estimated spawning biomass (tonnes) for the northern stock assessment regions for 1951-1987.

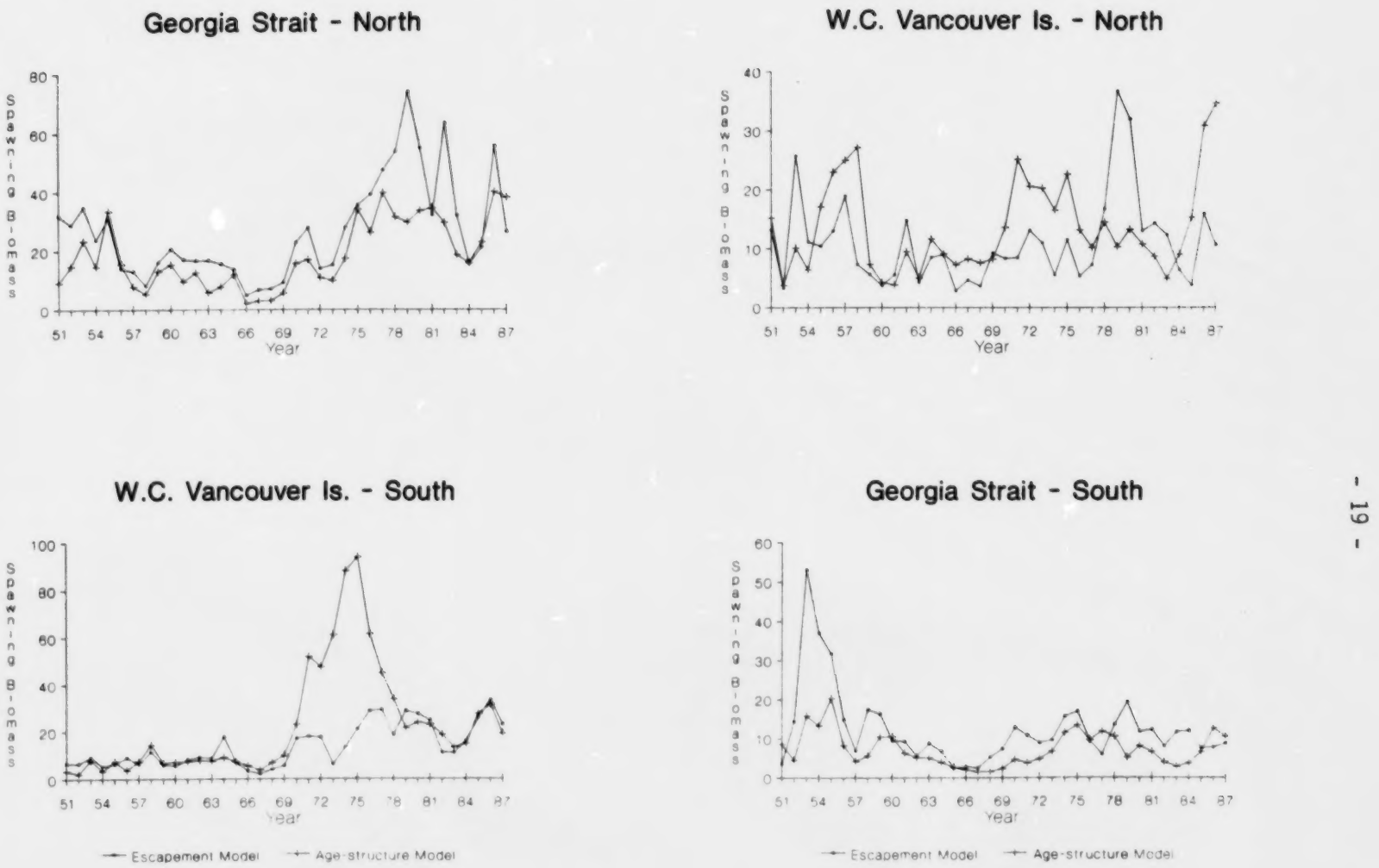

Fig. 2.2. Estimated spawning biomass (tonnes) for the southern stock assessment regions for 1951-1987.

3. AGE-STRUCTURED MODEL

3.1 INTRODUCTION

A modified version of the age-structured model described in Fournier and Archibald (1982), has been used to assess B.C. herring stocks since 1982. The model has undergone numerous revisions to make it more consistant with the life history of herring and the fisheries being analyzed. The current version which is described here, incorporates auxillary information in the form of spawn survey data, separates catch at age data by gear type, and includes an availability term to model partial recruitments to the spawning stock. The model includes realistic assumptions about the form of both measurement and process error. A maximum likelihood method is used to simultaneously estimate all model parameters.

3.2 METHODS

The Population Model

Two types of fishing gear are commonly used in B.C. herring fisheries. Of these, seine nets are assumed to be non-selective while gillnets are selective for larger, older fish. Herring fisheries have primarily concentrated on spawning fish or fish migrating to spawning grounds, so the relative availability of age classes to the non-selective gear should be equivalent to the partial recruitment of age-classes to the spawning stock. We have therefore developed a model which explicitly separates availability (partial recruitment) and selectivity. Seine and gillnet fisheries are temporally separate so catch-at-age data is partitioned into fishing periods, separating data for the different gears.

Let FN_{ij} be the total number of fish in age class j at the beginning of season i, and λ_{ij} be the proportion of age j fish which are available. Then N_{ij1}, the total number of age class j fish which are available in year i is given by

$$N_{ij1} = \lambda_{ij} \; FN_{ij} \tag{3.1}$$

To model the fishing process we assume that the Baranov (1918) catch equations are valid for the available fish,

$$C_{ijr} = \frac{F_{ijr}}{F_{ijr} + M_r} [\, 1 - \exp(-F_{ijr} - M_r)] \, N_{ijr},$$

and, for $r < p$

$$N_{ijr+1} = N_{ijr} \exp(-F_{ijr} - M_r),$$

where C_{ijr} is the catch of age class j in season i for period r
F_{ijr} is the fishing mortality of age class j in season i for period r
M_r is the natural mortality for period r
N_{ijr} is the number of fish in age class j in season i for period r
p is the number of fishing periods.
n is the number of seasons.

$N_{i+1,j+1,\ 1}$ is defined by equation 3.1 where for $j+1<K$

$$FN_{i+1,j+1} = N_{ijp} \exp(-F_{ijp}-M_r) + FN_{ij} (1 - \lambda_{ij}) \exp(\sum_r -M_r). \qquad (3.2)$$

In our model the last age class, k, accumulates fish aged k and older so for $j+1=k$ equation 3.2 is replaced by

$$FN_{i+1,k} = N_{ik-1p} \exp(-F_{ik-1p}-M_p) + FN_{ik-1} (1 - \lambda_{ik-1}) \exp(\sum_r -M_r) +$$

$$N_{i,k,p} \exp(-F_{i,k,p}-M_p) + FN_{i,k} (1 -\lambda_{ik}) \exp(\sum_r -M_r).$$

To reduce the number of parameters to be estimated we make certain restricting assumptions with respect to the availabities and mortalities. We make the assumption that availability increases with age, reaching a value of 1 when the entire cohort attains sexual maturity. The age of full maturity has been somewhat arbitrarily set at age 7. Additionally we assume that the availability of fish age 4 and older does not vary from year to year. However, the proportion of mature 3-year olds mature does vary between years (Haist and Stocker 1985) and some fisheries have targeted on immature 2-year old stocks (eg. 1957/58 Queen Charlotte Islands fishery, Appendix Table 1.1). We therefore parameterize availability for these two age classes with annual deviations from an average availability for the age class $\bar{}(\lambda j)$. Availability for ages 2 and 3 for years 1 to n-1 is

$$\lambda_{ij} = \bar{\lambda}_j + d_{ij},$$

where the d_{ij} are constrained such that

$$\sum_{i=1}^{n-1} d_{ij} = 0.$$

For ages 4 to 6 and ages 2 and 3 in year n

$$\lambda_{ij} = \bar{\lambda}_j,$$

and for ages 7 and older,

$$\lambda_{ij} = 1.$$

For selective fisheries we assume that fishing mortality is separable into an age selectivity component and a fishing intensity component. Following Doubleday (1976),

$$\log_e F_{ijr} = a_{ir} + b_{jr}$$

where a_{ir} represents the general level of fishing mortality due to fishery r in season i, and b_{jr} represents the relative vulnerability of age class j in fishery r. For non-selective fisheries the model is

$$\log_e F_{ijr} = a_{ir}.$$

We assume that natural mortality is constant over ages and seasons.

Additional structure is built into the model through the inclusion of annual spawning stock egg production data (spawn index) and the assumption of a stock-recruit relationship. Spawning occurs at the end of the season so the number of spawners at age j in season i (SN_{ij}) is estimated by

$$SN_{ij} = N_{ijp} \exp(-F_{ijp} - M_p).$$

and the reproductive potential (R_i) in season i is

$$R_i = \sum_j SN_{ij} f_j,$$

where f_j is the relative fecundity at age j. We assume the error in spawn index observations (SI_i) is multiplicative so that

$$SI_i = R_i \, q \exp(\epsilon_i) \qquad (3.3)$$

where q is a spawn index conversion factor and ϵ_i is a normally distributed random variable with mean 0 and variance σ_1^2. We assume a standard Ricker stock-recruit relationship with multiplicative error,

$$FN_{i+1,1} = \alpha \, R_i \exp(-\beta \, R_i) \exp(\epsilon_i), \qquad (3.4)$$

where ϵ_i is a normally distributed random variable with mean 0 and variance σ_2^2.

For the model described above the parameters to be estimated are:

FN_{i1} , for all seasons i
FN_{1j} , for age classes 2 to k
$\bar{\lambda}_j$, for age classes 2 to 7
d_{ij} , for age classes 2 and 3, for seasons 1 to N-1
a_{ir} , for all fisheries i,r
b_{jr} , for all selective fisheries
α, β, and q.

The $\bar{\lambda}_j$ and d_{ij} are reparameterized to constrain the values of λ_{ij} between 0 and 1. The parameters σ_1^2 and σ_2^2 are not estimated in the reconstructions, but are fixed at specified values as discussed later on.

The Objective Function

Data input to the stock reconstruction are:

S_{ijr} , the number of sampled fish aged j in season i for period r

O_{ir} , the estimated number of fish caught in period r of season i

f_j , the estimated fecundity at age j

We assume the same error structure for the observations S_{ijr} and O_{ir} as employed by Fournier and Archibald (1982), that is:

1) The S_{ijr} are obtained from ageing a random sample of fish from the catch and there are no ageing errors (i.e. a multinomial sampling distribution).
2) The error structure for the estimated number of fish caught (O_{ir}) is log-normal. That is

$$O_{ir} = C_{ir} \exp(\epsilon_i),$$

where C_{ir} is the actual number of fish caught in period j in season i ($C_{ir} = \sum_j C_{ijr}$) and the ϵ_i are independent normally distributed random variables with mean 0 and variance σ_3^2.
3) The random variables S_{ijr} and O_{ir} are independent.

Given the above stochastic assumptions the log-likelihood function for the parameters P_{ijr} ($P_{ijr} = C_{ijr}/C_{ir}$), C_{ir}, and σ_3^2 is

$$\sum_{ijr} S_{ijr} \log P_{ijr} - \sum_{ir} \frac{1}{2} \left(\frac{\log O_{ir} - \log C_{ir}}{\sigma_3^2} \right)^2 - n \log \sigma_3. \qquad (3.5)$$

The assumptions of log-normal measurement error in the observed spawn - actual spawn relationship and log-normal process error in the spawn-recruit relationship introduce the following contributions to the log - likelihood function

$$- \sum_i \frac{1}{2} [\log SI_i - \log (R_i q)]^2 / \sigma_1^2, \qquad (3.6)$$

from equation 3.2, and

$$- \sum_{j} \frac{1}{2} (\log FN_{i+1,1} - \log R_i - \log \alpha + \beta R_i)^2 / \sigma_2^2, \qquad (3.7)$$

from equation 3.3.

The objective function described above (eq. 3.5 + 3.6 + 3.7) incorporates both measurement (observational) and process (deviations from modelled relationships) error assumptions, with the relative magnitude of the errors related through the variance terms σ_1^2, σ_2^2, and σ_3^2, and the sample sizes $\sum_r S_{ijr}$. Because there is not enough information in the data to estimate the relative error in either the observations or processes, with the exception of scaling the S_{ijr}, the variance terms are not estimated but are held at fixed values. We assume the following variances:

$$\sigma_1^2 = .05,$$
$$\sigma_2^2 = .25,$$
$$\sigma_3^2 = .0025.$$

These correspond to approximately a 4% average error in estimating the total number of fish caught, an 18% average error in spawn index observations, and a 45% average deviation from the spawn-recruit relationship.

The actual number of fish aged, S_{ijr}, could be used in the objective function, however, we do not feel this would give a realistic estimate of the precision of the proportion at age data. That is, we do not feel the sampling process strictly adheres to binomial sampling assumptions. The between load (samples from different catching vessels) variability in age composition is significantly different between years, and this is more related to the spatial and temporal distribution of the fisheries than to the number of loads sampled or total fish aged. Therefore, we make use of the information in the subsamples (between load samples) which are pooled to obtain an estimate of the age composition for a given fishery.

The theoretical variance of the observed proportion of fish at age j ($\hat{p}_j$) for a random sample of size S is

$$\sigma^2_{\hat{p}_j} = \frac{p_j(1 - p_j)}{S}$$

where p_j is the true proportion at age j. We can calculate an estimate of the variance of $\hat{p}_j$,

$$s^2_{\hat{p}_j} = \sum_m \frac{(p_{jm} - \hat{p}_j)^2}{M - 1}$$

where p_{jm} is the proportion at age j in subsample m and M is the number of subsamples. This variance between subsamples results from the variance generated by randomly sampling an individual catch plus the variance in the true proportion at age between individual vessel catches. Using $\hat{p}_j$ as the best estimate for p_j we calculate the theoretical sample size (S') which would generate the observed variance at age j as,

$$S' = \frac{\hat{p}_j(1 - \hat{p}_j)}{s^2_{\hat{p}_j}}$$

We use these theoretical sample sizes, calculated from the between sample variance for 4-year old fish (Appendix Table 1), in the objective function.

Stock Forecasts

Forecasts of stock abundance for 1988 are calculated by assuming all natural mortality for the first period will occur prior to the fisheries. The numbers of fish at age prior to the fisheries are then the numbers estimated at the beginning of the 1987/88 season multipled by survival for the first period and the estimated availability at age. Recruitment is calculated for three scenarios based on estimated numbers at age 3 for the 1951-87 time series. Poor, average, and good recruitment are calculated as the mean of the lowest 33%, the mid 33%, and the highest 33% of historic age 3 numbers. Biomass is calculated using the average weights at age for roe seine fisheries in the final season.

To investigate the bias and variance of the estimated parameters, in particular current stock estimates and the stock forecast, we applied bootstrap techniques (Efron and Gong 1983) to each of the seven data sets. The bootstrap technique involves resampling the original data set with replacement to generate a new data matrix which has the same statistical properties as the original data set. To resample the age composition data we used a two stage procedure. First random subsamples were selected from the original data set, then individual fish were randomly selected from the subsample. Because we have no information about the error structure of the spawn observations or the total catch estimates these data were resampled under the same assumptions as used in the analytical model. That is, we assumed log normal errors with a variance of 0.05 and 0.0025 for the observed spawn and observed catch, respectively. The data for each stock grouping were resampled 50 times and reanalyzed producing 50 sets of parameter estimates.

Input data used for age-structured model analysis are shown in Appendix Table 1 for all stock groupings. Where no sample data are available, but catches were taken, the catch is included with an alternate fishery where age-structure data are available. The same spawn index is used as for last year's assessments. This index sums the lengths of spawnings multiplied by a width/intensity factor, standardized by section (Hay and Kronlund 1985).

3.3 RESULTS

Results from age-structured model stock reconstructions are shown in Appendix Table 2 for the seven major stock assessment regions. Estimates of spawning biomass in 1987 and forecasts of age 4 and recruit biomass for 1988 are shown in Table 3.1, and results of the bootstrap analysis are shown in Table 3.2.

To evaluate if the age-structured analysis produced biased estimates of current stock size and forecast stock biomass we applied a t-test under the null hypothesis that the bootstrap mean was no different than the original estimate. Only the Central Coast bootstrap mean was significantly different from the original estimate at the 5 percent level. Additional bootstap runs should be conducted to verify this result. In general the age-structured model estimates of current stock size do not appear to be biased. The standard error of the estimated biomasses range from 10% of the mean for the Prince Rupert District to 17% of the mean for the northern west coast of Vancouver Island stock assessment region.

For the Queen Charlotte Islands stock the reconstructions show a steady decline in spawning biomass over the past five seasons. The 1987 spawning biomass is only 33% of the biomass estimated for 1981; the decline in the spawn index is however, not as great. The 1987 spawning biomass was estimated at 16,200 tons and assuming average recruitment the forecast for 1988 is 15,000 t.

For the Prince Rupert District, age-structured analysis shows a stable spawning biomass since 1984 with an estimated 43,000 t of spawners in 1987. Current spawn levels are well above the long term average. Given average recruitment a run size of 44,500 t is forecast for this area.

The estimated 1987 spawning biomass for the Central coast is 20,000 tonnes from age-structured analysis. This represents a significant decline from the 1982 levels, which were estimated as the highest ever. However, the spawn index has not shown a major decline over the same time period. Forecast stock abundance for the Central coast in 1988 is estimated at 22,900 t given average recruitment.

Spawning biomass estimates for both the northern and southern Strait of Georgia are down slightly from 1986 levels. While this trend is consistant with the observed spawn index for the northern stock the spawn index for the southern stock increased in 1987. Forecasts for the northern and southern stocks in 1988, given average recruitment, are 41,200 and 13,600 t, respectively.

The spawning estimate for the southern west coast of Vancouver Island is down substantially from the 1986 biomass estimate. This is the result of an apparent poor recruitment of 3-year olds and a high catch rate. The forecast 1988 stock abundance is 22,600 t with average recruitment.

Age-structured model stock reconstructions for the northern west coast of Vancouver Island suggest a substantial increase in stock size over the past 4 seasons to a 1987 spawning biomass of 34,900 t. This estimate seems overly high given spawning estimate from synoptic dive surveys and in-season hydoacoustic estimates. Age-structured model estimates may be influenced by the high proportion of age 2 fish in this stock over the past four seasons. In addition, the bootstrap results indicate the greatest variability in 1987 spawning biomass for this stock, with estimates ranging from 24,600 to 47,500 t.

Table 3.1. Estimates of 1987 spawning biomass and forecasts of age 4+ and recruit biomass in 1988 (in thousands of tonnes) from age-structured model analysis.

Stock Assessment Region	1987 Spawning Biomass	1988 Forecasts			
		Age 4+	Age 3 recruits		
			Poor	Average	Good
Queen Charlotte Islands	16.2	12.2	0.9	2.8	10.1
Prince Rupert District	43.0	39.1	2.0	5.4	17.9
Central Coast	19.9	16.9	2.9	6.0	13.9
Strait of Georgia					
Northern stock	38.2	31.6	4.2	9.6	18.5
Southern stock	10.6	7.7	1.5	3.3	6.2
West Coast of Vancouver Is.					
Southern stock	19.1	14.8	3.7	7.8	19.0
Northern stock	34.9	27.9	1.8	5.7	11.2

Table 3.2. Bootstrap results of estimates of 1987 spawning biomass (tonnes) and forecast 1988 age 4+ biomass (tonnes) for herring stock assessment areas. For both parameters the original estimate, the bootstrap mean, the bootstap standard deviation, and the bootstrap range are given.

	1987 Spawning Biomass	1988 Age 4+ Biomass Forecast
Queen Charlotte Islands	16,240	12,162
bootstrap - mean	16,317	12,214
- st. dev.	2,362	1,736
- range	11,054 - 21,703	8,301 - 16,052
Prince Rupert District	43,026	39,075
bootstrap - mean	43,813	39,618
- st. dev.	4,310	3,859
- range	34,637 - 51,557	32,127 - 46,637
Central Coast	19,938	16,931
bootstrap - mean	19,287	16,348
- st. dev.	2,329	1,947
- range	13,307 - 23,377	11,662 - 19,774
Strait of Georgia		
Northern Stock	38,189	31,565
bootstrap - mean	39,034	32,315
- st. dev.	4,456	3,629
- range	29,287 - 47,052	23,971 - 39,166
Southern Stock	10,545	7,744
bootstrap - mean	10,406	7,704
- st. dev.	1,417	1,049
- range	7,945 - 14,155	6,053 - 11,019
W. Coast Vancouver Island		
Southern Stock	19,120	14,773
bootstrap - mean	19,245	14,821
- st. dev.	2,381	1,804
- range	15,105 - 25,101	11,599 - 19,310
Northern Stock	34,874	27,907
bootstrap - mean	33,999	27,134
- st. dev.	5,622	4,320
- range	24,565 - 47,456	19,336 - 38,346

4. CATCH RECOMMENDATIONS

We recommend catch levels at 20% of the forecast stock biomass for those stocks that are well above CUTOFF. The 20% harvest rate is based on an analysis of stock dynamics which indicates this level will stabilize both catch and spawning biomass while foregoing minimum yield over the long term. A fixed escapement policy would theoretically produce higher yields and spawning stock stability but is not attainable at the operational level. For those stocks which are marginally above CUTOFF we recommend the following reduced catch level:

Catch = Weighted Run - CUTOFF

This will provide for smaller fisheries for areas where the 20% harvest rate would bring the escapement down to levels below the CUTOFF.

CUTOFF levels are established at one-forth the unfished equilibrium biomass. The unfished equilibria were estimated from computer simulations. For the seven stock assessment regions the following CUTOFF levels have been estimated:

Queen Charlotte Islands	13,100 t
Prince Rupert District	8,900 t
Central Coast	11,100 t
Strait of Georgia-north	14,600 t
Strait of Georgia-south	6,200 t
W.C. Vancouver Is.-south	15,400 t
W.C. Vancouver Is.-north	6,000 t

To determine the "best" stock forecasts we used a two step procedure. First, for each of the two assessment methods, and for each stock group, one recruitment estimate was chosen, either poor, average, or good. The information used to choose the particular recruitment estimate included forecasts from either a stock-environment-recruitment model or time-series model and recent trends in stock and recruitment levels. Secondly, we assigned subjective probabilities to the alternate assessment models. Based on intuition and past performance, we believe the age-structured model makes the most likely predictions of forecast runs. The escapement model incorporates diving survey information on most major spawns in the south coast in 1987, and we feel these direct estimates of egg deposition provide a reasonably accurate estimate of current stock size. Hence, we used equal probabilities for the two models in most assessment regions. The only exception to this was for the northern west coast of Vancouver Island where age-structured analysis has produced inconsistant forecasts in recent years. This may result from a limited number of representative ageing samples for this area. Consequently, we felt that the age-structured model estimates for this region may be biased and we used a 80:20 weighting in favour of the escapement model for this area.

The assigned probabilities were used to weight the forecast "best" runs obtained from each method to provide a single "weighted run" for each of the stock groupings (Table 4.1).

The predicted level of recruitment to the Queen Charlotte Islands stock assessment region was average from a stock-environment-recruitment model (Stocker et al. 1988). However, because this stock has decreased steadily since 1981 and the trend of poor recruitments since the strong 1977 year-class has continued this year, the assumption of average recruitment may be too optimistic. Therefore, a recruitment level midway between poor and average was selected, resulting in a weighted forecast run of 12,130 tonnes. This forecast is marginally below the CUTOFF level so we recommend that no roe fishery take place in the Queen Charlotte Islands in 1988.

The Prince Rupert District spawning stock continues to be at historically high levels. Given the average to good recruitment levels in recent years, we feel an optimistic recruitment assumption may be warranted for 1988. Therefore, we assume a recruitment level midway between average and good for a forecast biomass of 43,750 tonnes. This produces a recommended catch of 8750 tonnes for the Prince Rupert District in 1988.

The recruitment forecast for the Central Coast based on the stock-environment model was for good recruitment from the 1985 year-class. Other stock indicators suggested that an average recruitment level was more probable and so a weighted forecast run with average recruitment of 23,800 tonnes was projected. The recommended catch for this region is 4760 tonnes.

The south coast stocks declined relative to 1986 when the strong 1983 year class boosted biomass levels in most areas. Recruitment forecasts to all stocks from time-series analysis predict average levels. The weighted forecast runs to the northern Strait of Georgia in 1988 was for 36,300 tonnes and to the southern strait 10,350 tonnes. The recommended catches for these areas are 7260 and 2070 tonnes, respectively.

The forecast run to the southern west coast of Vancouver Island is 23,000 tonnes for an allowable catch of 4600 tonnes. The forecast for the northern area, even with the low weighting on the age-structured model, is 16,560 tonnes for a recommended catch of 3310 tonnes.

The catch levels recommended in this summary are based purely on biological considerations, reflecting the best biological analyses given the available data bases. Management of the various fisheries has practical constraints not considered in this report. As well, there are economic considerations which are beyond the scope of our analysis. Hence, the quotas ultimately adopted by DFO may differ from those recommended herein.

Table 4.1. Summary of 1988 predicted stock biomass (1000t) from age-structured and escapement models and weighted runs for poor, average, and good recruitment levels.

	AGE STRUCTURED MODEL				ESCAPEMENT MODEL				WEIGHTED RESULTS			
		Stock + recruitment				Stock + recruitment				Stock with recruitment		
	AGE 4+	Poor	Avg.	Good	AGE 4+	Poor	Avg.	Good	Rel Weight	Poor	Avg.	Good
Queen Charlotte Islands	12.2	13.1	15.0	22.3	8.8	9.4	11.0	19.0	50:50	11.25	13.00	20.65
Prince Rupert District	39.1	41.1	44.5	57.0	27.6	28.8	31.8	41.7	50:50	34.95	38.15	49.35
Central Coast migratory stock	16.9	19.8	22.9	30.8	18.5	21.1	24.7	35.9	50:50	20.45	23.80	33.35
Strait of Georgia northern stock	31.6	35.8	41.2	50.1	18.9	25.2	31.4	43.6	50:50	30.50	36.30	46.85
southern stock	7.7	9.2	11.0	13.9	5.5	8.2	9.7	12.5	50:50	8.70	10.35	13.20
West Coast of Vancouver Is. southern stock	14.8	18.5	22.6	33.8	15.7	19.0	23.4	32.6	50:50	18.75	23.00	33.20
northern stock[a]	27.9	29.7	33.6	39.1	7.4	9.2	12.3	21.8	20:80	13.30	16.56	25.26

[a]Recruitment estimates based on data from roe fishery only.

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Appendix Table 1.1. Age composition and catch in numbers by fishery and season and weight at age averaged over all seasons for the Queen Charlotte Islands stock assessment region.

Season	Fishery	Percent at age 1	2	3	4	5	6	7	8	9	10	Number aged	Sample weight	Catch (x 10^{-5})
1950/51	REDUCTION	0.0	0.1	15.3	52.9	15.3	11.5	4.2	0.6	0.1	0.0	1476	1544	317.44
1951/52	REDUCTION	1.2	16.9	21.5	33.8	21.3	4.1	1.1	0.1	0.0	0.0	2251	165	1136.50
1953/54	REDUCTION	0.1	3.0	29.0	21.3	33.6	10.2	1.9	0.7	0.2	0.1	0[a]	25	231.77
1954/55	REDUCTION	0.0	8.7	14.1	39.4	18.1	14.8	4.4	0.3	0.1	0.1	0[a]	25	131.14
1955/56	REDUCTION	0.0	0.1	16.0	9.6	62.2	8.4	2.7	0.7	0.0	0.1	1348	681	6562.62
1956/57	REDUCTION	0.2	21.1	23.7	15.7	9.5	26.9	2.3	0.4	0.1	0.0	4649	2106	2234.96
1957/58	REDUCTION	0.0	81.9	16.4	1.2	0.2	0.1	0.1	0.0	0.0	0.0	2838	514	2149.80
1958/59	REDUCTION	0.0	1.1	63.2	28.4	7.4	0.0	0.0	0.0	0.0	0.0	95	6	757.14
1960/61	REDUCTION	0.0	4.2	32.6	36.0	24.8	1.3	0.4	0.2	0.4	0.0	0[a]	25	66.89
1961/62	REDUCTION	0.0	3.0	37.6	41.4	9.6	6.5	1.6	0.2	0.0	0.0	428	170	693.85
1962/63	REDUCTION	0.0	0.4	50.0	27.1	18.2	2.1	2.0	0.0	0.1	0.1	804	411	1367.40
1963/64	REDUCTION	0.0	0.9	15.3	59.5	17.8	5.3	1.1	0.0	0.0	0.0	528	297	2347.93
1964/65	REDUCTION	0.0	1.6	79.8	11.0	4.4	2.1	0.9	0.2	0.0	0.0	1053	165	3132.24
1965/66	REDUCTION	1.7	18.0	32.2	16.1	10.2	7.3	5.8	4.8	2.0	1.7	0[a]	25	213.13
1966/67	REDUCTION	0.0	0.9	67.3	26.5	2.7	2.7	0.0	0.0	0.0	0.0	0[a]	25	14.23
1967/68	REDUCTION	0.8	29.7	50.2	17.1	2.2	0.0	0.0	0.0	0.0	0.0	0[a]	25	8.48
1971/72	ROE-SN	0.0	4.7	37.6	46.5	4.5	4.5	1.5	0.4	0.2	0.0	465	54	90.92
1972/73	ROE-SN	0.0	0.3	37.3	19.7	32.8	6.8	2.4	0.7	0.0	0.0	702	869	148.90
1973/74	ROE-SN	0.0	0.3	59.7	23.4	9.6	5.3	1.1	0.4	0.1	0.0	697	272	195.48
	ROE-GN	0.0	0.0	1.4	37.5	29.2	25.0	5.6	0.0	0.0	1.4	72	72	4.02
1974/75	ROE-SN	0.0	0.1	33.3	45.4	13.5	5.3	1.7	0.5	0.2	0.0	3026	788	370.01[c]
	ROE-GN	0.0	0.0	0.0	22.5	40.0	30.0	5.0	2.5	0.0	0.0	40	40	6.19
1975/76	ROE-SN	0.0	0.3	2.9	52.8	33.5	7.6	2.2	0.6	0.0	0.0	2629	1293	690.30[e]
1976/77	ROE-SN	0.0	0.0	17.3	10.3	43.1	22.6	5.5	1.0	0.2	0.0	1824	653	688.84[ce]
1977/78	ROE-SN	0.0	0.1	24.7	17.1	11.1	33.0	12.2	1.7	0.0	0.0	784	1347	661.74[e]
1978/79	ROE-SN	0.0	5.6	4.4	31.6	18.7	21.3	15.1	2.8	0.4	0.1	1020	441	387.56[c]
	ROE-GN	0.0	0.0	0.0	25.1	25.1	25.1	20.1	3.5	0.5	0.5	199	65	128.20
1979/80	ROE-SN	0.0	0.3	85.3	4.5	4.9	2.5	1.8	0.6	0.1	0.0	2223	1399	143.46
	ROE-GN	0.0	0.0	4.5	4.0	40.5	20.5	24.5	5.0	1.1	0.0	756	1008	60.13

Appendix Table 1.1 (cont'd).

Season	Fishery	Percent at age 1	2	3	4	5	6	7	8	9	10	Number aged	Sample weight	Catch (x 10^{-5})
1980/81	ROE-SN	0.0	0.2	3.0	85.3	5.4	3.2	2.0	0.7	0.2	0.1	4586	424	331.01[c]
	ROE-GN	0.0	0.0	0.2	74.8	8.3	9.4	4.9	1.9	0.6	0.0	905	339	121.41
1981/82	ROE-SN	0.0	0.5	3.4	3.7	87.6	2.1	1.4	0.8	0.5	0.1	2813	1889	186.62[c]
	ROE-GN	0.0	0.0	0.2	3.4	88.2	3.4	2.7	1.1	0.8	0.2	526	341	99.20
1982/83	ROE-SN	0.0	4.1	4.8	3.5	6.4	74.9	3.7	1.5	0.8	0.2	1706	1282	316.02[c]
	ROE-GN	0.0	0.0	0.0	1.3	2.8	89.0	3.1	2.5	0.7	0.5	747	637	58.91
1983/84	OTHER	0.0	5.9	36.6	2.2	4.3	8.6	39.2	2.2	0.5	0.5	186	186	16.18
	ROE-SN	0.0	1.9	35.8	4.8	2.7	10.4	42.9	1.1	0.4	0.2	3013	1473	313.87
	ROE-GN	0.0	0.0	2.8	1.3	4.6	9.0	80.1	1.8	0.3	0.3	391	427	34.59
1984/85	ROE-SN	0.0	1.3	14.9	31.8	4.0	4.5	11.4	31.5	0.4	0.1	3556	699	311.61[c]
	ROE-GN	0.0	0.0	0.0	15.3	2.1	4.2	11.1	66.7	0.7	0.0	144	83	85.78
1985/86	ROE-SN	0.0	0.2	2.8	22.0	40.2	4.0	3.3	8.0	19.1	0.3	4733	2821	168.19
	ROE-GN	0.0	0.0	0.0	11.9	50.6	5.4	5.2	10.4	16.0	0.5	405	383	49.29
1986/87	ROE-SN	0.0	1.8	9.9	5.4	25.1	37.9	3.8	4.3	5.7	6.1	3096	1221	109.00

	Average weight at age (g)									
Fishery	1	2	3	4	5	6	7	8	9	10
REDUCTION	11.7	52.0	84.4	106.6	126.0	147.7	156.8	172.2	147.3	183.5
ROE-SN	0.0	66.8	99.1	127.3	151.5	173.9	189.4	202.1	211.1	210.0
ROE-GN	0.0	0.0	117.5	139.9	151.7	168.0	176.7	188.6	188.8	193.4
OTHER	11.7	60.6	93.6	119.6	142.3	165.6	179.0	194.4	200.2	202.3

[a]Age composition from published reports.
[b]No seine roe fishery in this season. Age composition from pre-fishery charter samples only.
[c]Includes catch from "other" fisheries
[d]Includes catch from seine roe fisheries
[e]Includes catch from gillnet fisheries

Appendix Table 1.2. Age composition and catch in numbers by fishery and season and weight at age averaged over all seasons for the Prince Rupert District stock assessment region.

Season	Fishery	Percent at age										Number aged	Sample weight	Catch ($\times 10^{-5}$)
		1	2	3	4	5	6	7	8	9	10			
1950/51	REDUCTION	0.0	4.3	18.2	58.5	10.4	5.6	2.6	0.3	0.0	0.0	4684	2202	4954.74
1951/52	REDUCTION	0.1	4.8	8.8	33.7	45.2	6.1	1.0	0.3	0.0	0.0	5925	2500	4392.63
1952/53	REDUCTION	0.0	1.2	38.1	23.0	25.4	11.1	1.0	0.1	0.0	0.0	1419	752	173.50
1953/54	REDUCTION	0.0	2.1	28.4	29.1	24.0	13.2	2.6	0.6	0.0	0.0	2656	891	2522.89
1954/55	REDUCTION	0.0	2.7	4.9	70.3	15.6	5.2	1.1	0.2	0.0	0.0	1131	467	1698.85
1955/56	REDUCTION	0.0	10.0	58.1	9.5	19.0	2.6	0.5	0.2	0.1	0.0	1683	555	1218.10
1956/57	REDUCTION	0.0	11.5	17.8	39.8	13.2	16.0	1.4	0.3	0.0	0.0	3491	515	2827.98
1957/58	REDUCTION	0.0	45.8	30.2	8.0	11.8	1.8	2.4	0.0	0.0	0.0	847	123	644.16
1958/59	REDUCTION	0.0	3.1	56.7	20.9	5.8	9.9	1.7	1.9	0.1	0.0	1741	349	1037.09
1959/60	REDUCTION	0.0	49.1	6.3	28.2	8.9	4.1	2.5	0.7	0.2	0.0	4206	337	2451.31
1960/61	REDUCTION	0.0	9.7	58.3	7.3	18.0	4.3	1.6	0.6	0.1	0.0	4300	763	4815.52
1961/62	REDUCTION	0.0	3.0	30.3	44.7	6.9	9.9	3.4	0.9	0.5	0.3	1845	752	2476.36
1962/63	REDUCTION	0.0	39.3	13.3	18.2	22.0	3.6	3.0	0.5	0.1	0.1	3415	433	4788.66
1963/64	REDUCTION	0.0	3.7	64.9	10.1	10.9	8.9	0.7	0.6	0.1	0.0	3400	1914	3555.87
1964/65	REDUCTION	0.0	6.0	13.6	51.0	8.5	11.0	8.5	1.0	0.3	0.1	3360	459	3649.12
1965/66	REDUCTION	0.0	0.0	5.3	21.4	23.4	16.3	19.1	9.7	3.2	1.6	435	59	1071.96
1966/67	REDUCTION	0.9	56.7	31.9	5.3	1.9	2.7	0.4	0.2	0.0	0.0	0[a]	25	1225.88
1967/68	REDUCTION	3.2	33.7	38.5	18.8	4.4	0.7	0.3	0.1	0.3	0.0	0[a]	25	281.72
1968/69	OTHER	1.3	29.7	44.5	20.3	3.8	0.2	0.2	0.0	0.0	0.0	0[a]	25	69.79
1969/70	OTHER	0.7	18.5	62.4	15.0	3.1	0.0	0.1	0.1	0.0	0.0	0[a]	25	184.71
1970/71	OTHER	0.0	6.5	50.4	29.3	8.0	4.3	0.8	0.5	0.2	0.0	601	38	413.67
1971/72	ROE-SN	0.0	0.0	5.3	17.9	64.4	5.9	3.8	2.4	0.1	0.1	714	209	278.66[ce]
1972/73	OTHER	0.0	22.9	47.7	7.8	13.1	4.6	2.6	1.3	0.0	0.0	153	14	35.70
	ROE-SN	0.0	0.3	33.0	4.4	30.4	26.6	3.4	1.3	0.8	0.0	797	662	94.37
1973/74	ROE-SN	0.0	0.2	17.9	53.2	7.4	16.5	4.4	0.3	0.2	0.0	632	121	174.36[c]
	ROE-GN	0.0	0.0	1.0	39.4	21.2	34.6	2.9	1.0	0.0	0.0	104	83	90.07
1974/75	OTHER	0.0	1.2	10.5	15.1	43.0	14.0	11.6	2.3	2.3	0.0	86	86	14.18
	ROE-SN	0.3	1.3	9.4	22.1	43.0	11.1	9.6	2.5	0.6	0.2	3084	769	116.58
	ROE-GN	0.0	0.0	0.0	31.9	59.6	8.5	0.0	0.0	0.0	0.0	47	47	0.76
1975/76	OTHER	0.0	0.0	4.9	6.8	9.9	16.7	17.9	35.2	8.6	0.0	162	1661	30.99
	ROE-SN	0.0	0.0	0.8	6.9	31.7	50.1	7.3	2.4	0.8	0.0	713	654	204.01
	ROE-GN	0.0	0.0	0.0	15.8	57.9	22.8	3.5	0.0	0.0	0.0	57	57	17.93
1976/77	OTHER	0.0	0.4	23.5	15.7	22.9	16.6	10.8	7.4	2.3	0.4	511	276	61.55
	ROE-SN	0.0	0.1	16.0	3.7	22.7	37.8	15.0	3.3	0.9	0.5	1310	1344	370.40
	ROE-GN	0.0	0.0	1.1	2.1	19.9	54.1	14.6	6.8	1.4	0.0	281	1104	89.48
1977/78	OTHER	0.0	1.3	9.6	27.8	18.2	18.1	14.6	6.9	2.4	1.0	982	124	238.36
	ROE-SN	0.0	1.1	11.7	32.8	9.6	21.1	20.4	2.4	0.6	0.3	795	131	136.94
	ROE-GN	0.0	0.0	0.0	20.5	6.0	32.5	33.1	6.6	1.3	0.0	151	37	181.42
1978/79	OTHER	0.0	1.8	9.3	9.8	25.9	17.8	16.2	9.5	5.7	4.0	1435	856	118.66
	ROE-SN	0.0	2.7	18.2	11.5	29.2	11.5	18.3	6.5	1.4	0.8	958	1475	84.40

Appendix Table 1.2 (cont'd).

Season	Fishery	Percent at age 1	2	3	4	5	6	7	8	9	10	Number aged	Sample weight	Catch (x 10^{-5})
	ROE-GN	0.0	1.1	1.1	8.0	41.4	15.7	22.2	8.0	1.9	0.4	261	255	74.00
1979/80	OTHER	0.0	1.1	61.2	6.5	7.9	8.2	6.5	4.9	2.1	1.6	1161	560	66.18
	ROE-SN	0.0	0.6	77.9	7.3	5.1	3.8	3.5	1.3	0.4	0.1	2811	535	171.81
	ROE-GN	0.0	0.0	3.4	8.7	31.2	22.3	21.1	9.1	3.4	0.6	493	915	63.73
1980/81	OTHER	0.0	1.0	7.4	54.6	9.3	10.2	9.3	4.3	2.3	1.5	6524	1129	137.14
	ROE-SN	0.0	0.5	11.2	81.2	3.3	1.7	1.5	0.4	0.2	0.1	3238	1059	106.00
	ROE-GN	0.0	0.0	0.5	38.9	15.5	23.0	14.8	5.6	1.9	0.0	427	557	23.77
1981/82	OTHER	0.0	1.5	11.5	20.5	41.1	10.5	6.6	5.0	2.1	1.1	2669	555	138.82
	ROE-SN	0.0	2.7	18.8	7.4	66.3	2.8	1.4	0.4	0.2	0.0	1544	576	16.50
1982/83	ROE-SN	0.0	1.4	20.8	17.7	5.3	49.2	3.7	1.1	0.6	0.2	4583	1448	1.00[b]
1983/84	OTHER	0.0	2.8	36.2	15.7	13.9	9.8	16.4	2.8	1.1	1.4	654	303	23.68
	ROE-SN	0.0	0.5	35.5	14.4	10.3	14.4	23.6	1.0	0.2	0.1	2837	618	159.00
	ROE-GN	0.0	0.0	1.0	2.0	12.9	21.4	57.4	3.4	1.2	0.8	505	961	127.31
1984/85	OTHER	0.0	15.4	8.2	25.8	28.2	11.7	5.4	4.1	0.8	0.3	631	45	28.24
	ROE-SN	0.0	0.2	7.8	54.7	11.9	6.4	10.6	8.2	0.1	0.1	3664	969	278.16
	ROE-GN	0.0	0.0	0.4	16.4	14.9	15.8	21.8	29.8	0.4	0.5	550	543	235.00
1985/86	ROE-SN	0.0	1.8	13.8	9.4	46.3	10.8	5.3	7.1	5.5	0.1	5655	4566	256.04
	ROE-GN	0.0	0.0	0.4	4.3	53.8	19.0	8.7	7.8	5.7	0.2	1274	558	333.56
1986/87	ROE-SN	0.0	0.9	38.6	10.2	6.9	29.9	5.9	3.5	2.9	1.2	4731	4068	129.04
	ROE-GN	0.0	0.0	0.6	3.0	6.9	55.3	16.1	8.8	6.0	3.4	1761	819	268.62

	Average weight at age (g)									
FISHERY	1	2	3	4	5	6	7	8	9	10
REDUCTION	21.8	43.9	79.3	107.9	128.2	146.1	163.1	173.5	188.7	206.8
ROE-SN	8.6	53.2	85.0	116.1	141.0	159.9	174.2	188.3	197.6	208.4
ROE-GN	0.0	90.3	114.0	136.6	148.8	164.3	171.6	179.5	191.8	197.4
OTHER	17.4	46.5	81.1	110.9	133.9	152.0	167.4	179.7	189.8	205.3

[a]Age composition from published reports.
[b]No seine roe fishery in this season. Age composition from pre-fishery charter samples only.
[c]Includes catch from "other" fisheries
[d]Includes catch from seine roe fisheries
[e]Includes catch from gillnet fisheries

Appendix Table 1.3. Age composition and catch in numbers by fishery and season and weight at age averaged over all seasons for the Central Coast stock assessment region.

Season	Fishery	Percent at age 1	2	3	4	5	6	7	8	9	10	Number aged	Sample weight	Catch (x 10^{-5})
1950/51	REDUCTION	0.0	2.4	28.5	50.6	12.0	5.1	1.2	0.1	0.0	0.0	5318	2484	3853.75
1951/52	REDUCTION	1.1	5.1	19.9	29.7	37.7	4.4	1.5	0.4	0.0	0.0	5214	1352	2895.10
1952/53	REDUCTION	0.4	9.3	28.0	23.9	26.5	10.1	1.3	0.4	0.0	0.0	2939	537	73.85
1953/54	REDUCTION	0.0	1.7	70.6	21.4	4.7	1.3	0.1	0.0	0.1	0.0	2999	541	3304.89
1954/55	REDUCTION	0.0	4.2	7.3	77.2	9.3	1.6	0.4	0.0	0.0	0.0	2254	310	1197.84
1955/56	REDUCTION	0.0	15.6	12.8	9.3	58.9	3.0	0.3	0.0	0.0	0.0	4876	1308	4023.84
1956/57	REDUCTION	0.0	16.9	50.9	10.8	6.1	14.7	0.7	0.0	0.0	0.0	4641	1668	2643.75
1957/58	REDUCTION	0.0	23.5	61.4	12.7	1.3	0.6	0.6	0.0	0.0	0.0	3743	847	1445.86
1958/59	REDUCTION	0.4	3.8	49.3	36.7	8.1	0.8	0.4	0.4	0.0	0.0	4996	1337	3305.21
1959/60	REDUCTION	0.0	50.9	19.4	24.3	4.5	0.6	0.1	0.1	0.0	0.0	1078	103	584.89
1960/61	REDUCTION	0.0	19.6	31.3	9.6	30.2	8.6	0.7	0.1	0.0	0.0	2198	833	2394.63
1961/62	REDUCTION	0.0	8.9	48.7	22.6	3.3	13.3	3.0	0.2	0.0	0.0	571	99	922.28
1962/63	REDUCTION	0.0	0.4	30.3	58.4	5.0	2.7	3.1	0.2	0.0	0.0	1038	860	3557.49
1963/64	REDUCTION	0.0	11.4	47.1	29.3	10.5	1.6	0.1	0.0	0.0	0.0	1064	180	3207.79
1964/65	REDUCTION	0.0	7.7	36.3	34.1	15.8	5.6	0.4	0.1	0.0	0.0	1512	580	1309.71
1965/66	REDUCTION	8.7	61.5	18.7	6.7	3.3	1.0	0.2	0.0	0.0	0.0	0[a]	25	5290.63
1966/67	REDUCTION	1.2	37.0	45.6	12.9	2.0	1.0	0.2	0.1	0.0	0.0	0[a]	25	2444.48
1967/68	REDUCTION	1.8	32.0	47.2	16.7	2.1	0.3	0.0	0.1	0.0	0.0	0[a]	25	164.60
1968/69	OTHER	16.1	27.0	23.2	22.4	9.5	1.6	0.1	0.0	0.0	0.0	0[a]	25	11.56
1969/70	OTHER	39.5	32.7	26.9	0.7	0.2	0.0	0.0	0.0	0.0	0.0	0[a]	25	39.77
1970/71	OTHER	0.1	14.4	39.6	36.8	3.8	4.2	0.9	0.1	0.1	0.0	953	135	339.63
1971/72	ROE-SN	0.0	4.4	29.8	27.7	25.7	6.9	4.4	1.1	0.1	0.0	1837	598	675.33[c]
	ROE-GN	0.0	0.0	0.9	14.9	65.0	10.6	7.9	0.6	0.0	0.0	329	503	8.47
1972/73	ROE-SN	0.0	1.2	50.5	18.6	15.5	11.7	1.9	0.5	0.2	0.0	1328	593	537.76[c]
	ROE-GN	0.0	0.0	2.5	25.3	44.9	20.9	4.4	1.3	0.6	0.0	158	114	71.26
1973/74	ROE-SN	0.0	2.8	17.7	38.6	19.7	13.4	6.6	0.9	0.3	0.0	1587	202	273.68
	ROE-GN	0.0	0.0	0.4	22.4	38.8	24.5	12.2	1.7	0.0	0.0	474	83	332.30
1974/75	ROE-SN	0.3	0.9	32.8	25.5	28.1	8.5	3.2	0.7	0.1	0.0	8651	3262	276.96
	ROE-GN	0.0	0.0	3.3	25.6	46.2	16.4	6.4	2.1	0.0	0.0	519	117	347.32
1975/76	ROE-SN	0.0	2.4	11.5	41.3	21.2	17.2	4.7	1.5	0.2	0.0	5243	978	477.80
	ROE-GN	0.0	0.0	0.8	18.8	29.8	35.3	11.8	3.0	0.4	0.1	1222	253	383.45
1976/77	OTHER	0.0	1.0	32.8	18.7	29.8	8.1	6.6	3.0	0.0	0.0	198	144	32.75
	ROE-SN	0.0	0.7	17.4	22.6	31.8	16.6	8.5	1.9	0.4	0.0	2496	925	284.27
	ROE-GN	0.0	0.0	1.1	13.0	35.5	31.6	13.5	4.0	1.3	0.0	453	169	411.71
1977/78	ROE-SN	0.0	0.2	25.7	15.2	19.9	23.1	10.9	3.5	1.1	0.4	1396	589	354.31
	ROE-GN	0.0	0.0	1.3	8.9	29.6	38.1	17.7	3.8	0.5	0.1	1075	474	576.00
1979/80	ROE-SN	0.0	3.6	73.5	6.3	8.8	3.9	2.6	0.7	0.4	0.1	2504	1337	1.12[c]
	ROE-GN	0.0	0.0	3.3	2.6	24.8	23.7	26.3	11.3	6.6	1.5	274	210	32.46
1980/81	ROE-SN	0.0	2.0	12.3	66.6	8.4	7.0	2.6	0.6	0.3	0.1	2952	492	25.75[c]
	ROE-GN	0.0	0.3	1.5	50.7	13.6	15.4	10.6	5.5	1.8	0.7	1536	276	163.04

Appendix Table 1.3 (cont'd).

Season	Fishery	Percent at age 1	2	3	4	5	6	7	8	9	10	Number aged	Sample weight	Catch ($\times 10^{-5}$)
1981/82	ROE-SN	0.0	1.7	14.9	10.7	60.9	5.3	4.5	1.5	0.5	0.0	3414	2184	187.25[c]
	ROE-GN	0.0	0.0	2.4	5.9	76.0	6.7	5.9	2.3	0.7	0.1	1337	301	287.08
1982/83	ROE-SN	0.0	0.5	7.0	15.4	10.8	57.1	5.0	3.1	0.7	0.3	5445	1082	154.75
	ROE-GN	0.0	0.0	0.5	7.2	13.1	69.4	5.0	3.9	0.6	0.3	1793	994	244.49
1983/84	ROE-SN	0.0	4.4	7.3	10.1	18.2	16.1	40.7	2.3	0.8	0.1	6294	2209	284.16[c]
	ROE-GN	0.0	0.0	0.3	2.9	13.1	17.3	60.1	4.7	1.1	0.5	1159	338	242.25
1984/85	ROE-SN	0.0	2.7	37.5	7.5	8.6	13.1	11.9	18.2	0.4	0.1	5157	5529	222.13
	ROE-GN	0.0	0.0	3.2	5.4	9.4	19.5	22.5	38.2	1.0	0.8	1288	1407	143.53
1985/86	ROE-SN	0.0	3.9	16.3	40.1	8.7	6.2	6.8	6.1	11.4	0.6	5729	2032	126.20
	ROE-GN	0.0	0.0	1.8	23.9	12.0	10.0	16.0	13.2	22.3	0.8	1069	262	68.15
1986/87	ROE-SN	0.0	4.1	22.6	14.6	32.2	5.7	4.5	5.8	4.7	5.8	5038	2319	168.41
	ROE-GN	0.0	0.0	0.8	7.7	44.9	11.7	7.8	9.9	8.2	9.0	981	1199	53.76

	Average weight at age (g)									
FISHERY	1	2	3	4	5	6	7	8	9	10
REDUCTION	17.6	44.8	80.7	105.1	126.2	138.7	150.9	157.3	143.8	164.0
ROE-SN	16.0	54.9	89.3	115.5	136.9	154.8	169.3	183.6	196.7	209.9
ROE-GN	0.0	39.3	112.9	137.6	150.3	162.1	171.6	182.8	190.4	187.3
OTHER	17.3	49.3	85.3	110.5	131.9	146.8	160.6	172.0	183.4	203.3

[a]Age composition from published reports.
[b]No seine roe fishery in this season. Age composition from pre-fishery charter samples only.
[c]Includes catch from "other" fisheries
[d]Includes catch from seine roe fisheries
[e]Includes catch from gillnet fisheries

Appendix Table 1.4. Age composition and catch in numbers by fishery and season and weight at age averaged over all seasons for the northern Strait of Georgia stock assessment region.

Season	Fishery	Percent at age 1	2	3	4	5	6	7	8	9	10	Number aged	Sample weight	Catch (x 10^{-5})
1950/51	REDUCTION	0.1	3.5	45.5	38.5	9.5	2.1	0.6	0.2	0.0	0.0	3554	526	1733.55
1951/52	REDUCTION	0.1	13.0	52.2	26.4	6.8	1.5	0.1	0.0	0.0	0.0	4533	570	1857.54
1952/53	REDUCTION	0.4	12.9	49.7	30.3	4.8	1.6	0.3	0.1	0.0	0.0	5343	707	545.54
1953/54	REDUCTION	0.0	2.3	34.0	39.2	16.7	5.7	1.7	0.4	0.0	0.0	6856	2388	1906.18
1954/55	REDUCTION	0.0	5.5	40.9	44.2	7.7	1.6	0.1	0.0	0.0	0.0	2657	360	2903.78
1955/56	REDUCTION	0.0	9.5	16.4	28.1	36.9	7.4	1.2	0.4	0.1	0.0	4919	925	2587.73
1956/57	REDUCTION	0.0	0.9	36.8	25.1	24.3	11.5	1.3	0.1	0.0	0.0	2420	497	1848.17
1957/58	REDUCTION	0.0	6.4	44.3	23.4	9.5	9.6	5.8	0.8	0.1	0.0	3473	617	890.18
1958/59	REDUCTION	0.8	16.8	62.4	16.3	2.8	0.5	0.3	0.1	0.0	0.0	4454	1799	4185.81
1959/60	REDUCTION	0.0	14.1	39.7	39.2	5.8	0.8	0.3	0.1	0.0	0.1	1252	231	2365.00
1960/61	REDUCTION	0.0	21.7	22.8	30.0	22.0	3.1	0.4	0.0	0.0	0.0	1302	222	1759.31
1961/62	REDUCTION	0.0	13.3	63.4	12.7	7.2	2.8	0.6	0.0	0.0	0.0	1506	584	3439.28
1962/63	REDUCTION	0.0	20.8	48.3	24.5	3.4	1.8	0.9	0.2	0.0	0.0	1161	144	4278.29
1963/64	REDUCTION	0.0	5.8	64.7	26.5	2.3	0.6	0.1	0.0	0.0	0.0	2224	639	3713.96
1964/65	REDUCTION	0.2	14.1	53.3	28.3	2.7	1.1	0.3	0.1	0.0	0.0	2095	529	2601.85
1965/66	REDUCTION	0.0	19.5	36.8	23.0	15.9	3.2	1.6	0.0	0.0	0.0	435	77	1848.84
1966/67	REDUCTION	8.1	28.4	47.7	10.5	3.0	1.9	0.3	0.0	0.0	0.0	0[a]	25	1196.04
1967/68	REDUCTION	13.0	20.0	50.6	13.0	2.5	0.6	0.2	0.1	0.0	0.0	0[a]	25	102.02
1968/69	OTHER	18.2	59.4	19.6	2.4	0.4	0.0	0.0	0.0	0.0	0.0	0[a]	25	51.02
1969/70	OTHER	0.6	23.6	62.9	11.1	1.4	0.5	0.0	0.0	0.0	0.0	0[a]	25	51.64
1970/71	OTHER	0.5	12.9	42.3	34.4	6.6	2.8	0.5	0.0	0.0	0.0	1060	239	82.55
1971/72	OTHER	0.0	1.5	27.6	36.8	26.1	5.4	2.3	0.3	0.0	0.0	1039	3596	55.97
	ROE-SN	0.0	4.2	39.3	31.5	19.5	4.3	1.1	0.0	0.0	0.0	2586	265	469.55
	ROE-GN	0.0	1.1	12.5	50.2	28.0	6.5	1.1	0.4	0.4	0.0	279	214	0.12
1972/73	OTHER	0.1	0.5	23.5	33.0	26.8	13.9	1.9	0.3	0.0	0.0	3915	1785	264.85
	ROE-SN	0.0	4.2	54.9	21.4	12.9	6.1	0.5	0.0	0.0	0.0	379	615	137.00
	ROE-GN	0.0	0.0	5.5	27.3	52.7	10.9	3.6	0.0	0.0	0.0	55	55	87.20
1973/74	ROE-GN	0.0	0.0	3.6	43.1	33.1	16.9	2.9	0.3	0.0	0.0	661	320	204.02[cd]
1974/75	OTHER	1.1	22.1	60.4	12.3	2.1	1.4	0.5	0.0	0.2	0.0	439	15	65.64
	ROE-SN	1.7	3.5	57.3	27.0	7.1	2.6	0.5	0.2	0.1	0.0	3092	662	50.23
	ROE-GN	0.0	0.0	6.7	31.9	43.7	13.4	3.4	0.8	0.0	0.0	119	26	283.37
1975/76	OTHER	0.1	7.9	17.6	34.9	25.5	8.6	3.7	1.3	0.2	0.1	1380	553	150.55
	ROE-SN	0.0	13.3	26.3	43.3	14.1	2.2	0.3	0.4	0.0	0.0	729	97	20.92
	ROE-GN	0.0	0.0	0.5	39.1	44.0	12.9	3.0	0.4	0.1	0.0	737	269	405.21
1976/77	OTHER	0.0	3.2	19.7	24.8	36.9	14.6	0.6	0.0	0.0	0.0	157	254	46.34
	ROE-SN	0.1	3.3	57.8	20.8	14.4	3.0	0.4	0.2	0.0	0.0	2234	1269	370.86
	ROE-GN	0.0	0.0	3.2	26.1	48.7	17.2	4.1	0.6	0.1	0.0	1423	162	466.14
1977/78	OTHER	0.1	4.7	38.0	28.4	9.6	11.6	5.7	1.2	0.5	0.1	758	205	364.13
	ROE-SN	0.0	0.8	34.8	42.8	11.9	7.7	1.5	0.3	0.0	0.1	3146	2299	353.53
	ROE-GN	0.0	0.0	0.4	19.7	31.4	35.1	11.3	1.7	0.4	0.0	462	690	426.90

Appendix Table 1.4 (cont'd).

Season	Fishery	Percent at age 1	2	3	4	5	6	7	8	9	10	Number aged	Sample weight	Catch (x 10^{-5})
1978/79	OTHER	0.0	1.2	16.2	36.6	25.3	10.9	7.7	1.6	0.4	0.1	764	201	164.24
	ROE-SN	0.0	1.0	17.7	31.0	34.5	10.2	5.8	1.5	0.2	0.0	889	311	1.00[b]
	ROE-GN	0.0	0.0	1.2	23.2	54.7	13.5	5.8	1.5	0.0	0.2	607	290	441.80
1979/80	OTHER	1.4	5.0	40.4	21.9	18.6	8.1	2.8	1.5	0.3	0.0	2101	1071	126.23
	ROE-SN	0.0	2.4	48.5	16.2	18.1	10.5	2.6	1.3	0.3	0.1	3461	1451	16.86
	ROE-GN	0.0	0.0	2.0	9.2	44.6	33.4	8.8	1.9	0.3	0.0	754	1139	215.21
1980/81	OTHER	0.0	1.8	40.6	36.5	13.3	4.7	2.1	0.5	0.5	0.0	655	212	23.02
	ROE-SN	0.0	6.9	37.0	30.1	11.4	9.6	3.9	0.6	0.3	0.0	6893	2295	201.50
	ROE-GN	0.0	0.1	2.2	18.2	23.0	37.4	16.1	2.8	0.3	0.1	1140	338	333.10
1981/82	OTHER	0.0	0.0	25.8	35.2	28.3	4.4	2.5	2.5	0.0	1.3	159	123	10.00
	ROE-SN	0.0	6.9	31.4	24.8	21.1	5.6	6.3	3.0	0.9	0.1	2244	1051	1.00[b]
	ROE-GN	0.0	0.0	4.4	15.4	28.5	14.8	20.8	14.2	1.7	0.4	833	543	367.36
1982/83	OTHER	0.0	27.2	47.2	13.9	7.8	2.8	0.0	1.1	0.0	0.0	180	523	10.56
	ROE-SN	0.0	2.4	31.6	28.4	17.8	12.1	3.3	2.9	1.2	0.2	9747	6013	675.25
	ROE-GN	0.0	0.0	0.5	27.8	29.5	23.6	9.3	7.4	1.7	0.2	407	305	563.81
1983/84	OTHER	0.0	8.7	39.4	28.5	11.0	7.3	3.7	1.4	0.0	0.0	355	66	19.33
	ROE-SN	0.0	4.7	39.3	31.4	12.8	6.6	3.5	1.0	0.5	0.1	5747	1917	351.51
	ROE-GN	0.0	0.0	7.0	30.2	31.1	19.2	9.3	1.7	0.7	0.9	766	759	421.50
1984/85	OTHER	0.0	13.1	50.8	20.3	10.2	4.0	1.3	0.3	0.0	0.0	679	380	10.32
	ROE-SN	0.0	22.0	45.1	19.4	8.6	3.1	1.3	0.5	0.1	0.0	5580	2423	287.19
	ROE-GN	0.0	0.1	3.1	26.1	32.5	23.6	9.2	3.7	0.8	0.8	1096	650	237.16
1985/86	ROE-SN	0.1	9.1	54.2	26.0	7.3	2.3	0.9	0.2	0.0	0.0	4105	1391	1.00[b]
1986/87	ROE-SN	0.0	6.0	31.3	39.6	17.3	4.0	1.2	0.4	0.2	0.1	5965	2571	310.39
	ROE-GN	0.0	0.0	2.0	32.7	34.5	17.6	9.7	2.7	0.5	0.3	1277	652	151.76

FISHERY	Average weight at age (g) 1	2	3	4	5	6	7	8	9	10
REDUCTION	14.9	45.6	83.9	110.5	133.2	149.7	168.6	174.4	194.0	188.3
ROE-SN	16.5	56.4	82.8	111.2	132.4	151.3	168.5	178.7	175.3	185.7
ROE-GN	0.0	67.2	118.8	137.4	149.9	161.9	170.5	183.4	181.5	182.8
OTHER	16.4	51.2	84.6	111.2	133.6	151.8	169.9	171.6	176.8	181.0

[a]Age composition from published reports.
[b]No seine roe fishery in this season. Age composition from pre-fishery charter samples only.
[c]includes catch from "other" fisheries
[d]includes catch from seine roe fisheries
[e]includes catch from gillnet fisheries

Appendix Table 1.5. Age composition and catch in numbers by fishery and season and weight at age averaged over all seasons for the southern Strait of Georgia stock assessment region.

Season	Fishery	Percent at age										Number aged	Sample weight	Catch ($\times 10^{-5}$)
		1	2	3	4	5	6	7	8	9	10			
1950/51	REDUCTION	0.0	4.7	65.6	23.5	5.1	0.9	0.1	0.0	0.0	0.0	4262	1605	2688.26
1951/52	REDUCTION	0.1	9.3	58.5	23.7	6.7	1.2	0.4	0.1	0.0	0.0	4499	1222	2966.21
1952/53	REDUCTION	0.1	3.9	65.9	26.6	3.0	0.6	0.0	0.0	0.0	0.0	3320	1258	493.14
1953/54	REDUCTION	0.0	0.7	58.4	34.2	5.9	0.6	0.1	0.0	0.0	0.0	6306	2318	4668.76
1954/55	REDUCTION	0.0	3.3	56.4	33.8	5.7	0.6	0.1	0.0	0.0	0.0	2634	714	4115.48
1955/56	REDUCTION	0.0	4.5	53.8	29.5	10.4	1.5	0.2	0.0	0.0	0.0	4913	2414	4726.81
1956/57	REDUCTION	0.0	1.6	70.8	21.0	4.2	2.0	0.3	0.1	0.0	0.0	5059	2139	4146.45
1957/58	REDUCTION	0.0	11.3	63.5	21.0	2.9	1.0	0.3	0.1	0.0	0.0	3924	1050	1379.36
1958/59	REDUCTION	0.8	17.1	64.2	14.6	2.4	0.6	0.2	0.1	0.0	0.0	5586	2067	1946.50
1959/60	REDUCTION	0.0	4.5	57.2	35.2	2.5	0.4	0.1	0.1	0.0	0.0	2490	1351	4499.74
1960/61	REDUCTION	0.0	35.7	29.1	25.5	8.8	0.8	0.1	0.0	0.0	0.0	3049	620	3469.79
1961/62	REDUCTION	0.0	5.2	76.0	13.6	3.6	1.4	0.2	0.1	0.0	0.0	1697	412	3696.98
1962/63	REDUCTION	0.0	14.4	53.6	29.2	2.6	0.2	0.1	0.0	0.0	0.0	1148	308	3870.31
1963/64	REDUCTION	0.1	6.2	56.3	34.0	2.9	0.4	0.1	0.1	0.0	0.0	1804	625	3796.46
1964/65	REDUCTION	0.0	16.2	58.1	22.6	2.3	0.7	0.0	0.2	0.0	0.0	1259	451	1965.81
1965/66	REDUCTION	0.0	31.0	32.7	23.8	11.1	1.0	0.5	0.0	0.0	0.0	416	36	1332.91
1966/67	REDUCTION	13.6	37.4	33.8	11.2	2.7	1.0	0.2	0.0	0.1	0.0	0[a]	25	2516.94
1967/68	REDUCTION	69.3	15.8	9.0	4.3	1.0	0.4	0.0	0.2	0.0	0.0	0[a]	25	245.19
1968/69	OTHER	24.6	38.1	23.0	10.4	2.8	1.1	0.0	0.0	0.0	0.0	0[a]	25	60.68
1969/70	OTHER	0.4	27.4	57.2	7.8	5.1	1.0	1.1	0.0	0.0	0.0	0[a]	25	38.15
1970/71	OTHER	0.0	10.6	33.4	42.1	8.6	2.8	2.2	0.3	0.0	0.0	359	162	64.38
1971/72	OTHER	0.0	13.8	33.5	33.8	15.1	2.7	1.0	0.1	0.0	0.0	2625	807	154.95
	ROE-SN	0.0	14.0	28.6	36.0	17.4	2.8	1.0	0.2	0.0	0.0	2263	597	38.49
	ROE-GN	0.0	5.7	11.1	45.1	29.4	7.0	1.6	0.1	0.0	0.0	756	151	9.59
1972/73	OTHER	0.0	3.4	49.6	21.2	18.6	5.5	1.1	0.5	0.1	0.0	797	203	27.12
	ROE-GN	0.0	0.0	21.3	31.4	32.5	11.2	3.0	0.6	0.0	0.0	169	56	43.63
1973/74	OTHER	0.0	17.4	73.3	8.1	1.2	0.0	0.0	0.0	0.0	0.0	86	86	39.04
	ROE-GN	0.0	0.0	7.3	40.4	27.7	16.1	6.4	2.1	0.0	0.0	329	268	30.21
1974/75	ROE-SN	0.0	3.9	50.1	28.6	8.7	4.3	3.1	0.9	0.3	0.0	2154	597	2.49[c]
	ROE-GN	0.0	0.0	1.6	64.5	21.0	9.7	3.2	0.0	0.0	0.0	62	62	68.22
1975/76	OTHER	0.0	5.5	21.7	44.3	19.7	5.2	2.3	0.8	0.5	0.0	3023	965	249.87
	ROE-SN	0.0	9.6	22.1	35.5	16.0	5.6	6.1	3.6	1.3	0.3	394	108	1.00[b]
	ROE-GN	0.0	0.0	0.7	41.5	41.5	11.6	2.7	2.0	0.0	0.0	147	126	63.84
1976/77	OTHER	0.6	4.2	52.5	21.7	15.2	3.8	1.3	0.5	0.2	0.1	2512	788	472.92
	ROE-SN	0.0	4.8	18.4	8.0	15.2	19.2	16.0	11.2	4.8	2.4	125	136	23.00
	ROE-GN	0.0	0.0	4.6	48.6	35.4	10.3	1.1	0.0	0.0	0.0	175	5	48.06
1977/78	OTHER	0.0	1.2	35.1	45.8	10.6	5.6	1.3	0.1	0.2	0.1	1709	391	819.26
	ROE-SN	0.0	1.1	40.5	46.2	7.5	4.3	0.4	0.0	0.0	0.0	279	132	1.00[b]
	ROE-GN	0.0	0.0	1.9	23.1	24.0	38.5	12.5	0.0	0.0	0.0	104	433	57.85
1978/79	OTHER	0.0	1.9	18.6	37.8	29.0	8.0	3.3	1.0	0.3	0.1	4699	1796	922.01

Appendix Table 1.5 (cont'd).

Season	Fishery	Percent at age 1	2	3	4	5	6	7	8	9	10	Number aged	Sample weight	Catch (x 10^{-5})
	ROE-SN	0.0	2.7	24.0	35.6	20.2	7.9	4.0	3.1	1.3	1.2	520	98	1.00[b]
1979/80	OTHER	0.0	1.4	45.4	24.0	17.7	8.4	1.7	1.1	0.3	0.1	2842	1954	109.21
	ROE-SN	0.0	3.0	57.9	12.0	15.9	6.8	2.9	0.8	0.2	0.5	591	189	1.00[b]
1980/81	OTHER	0.0	3.9	33.3	33.9	15.9	9.1	3.2	0.5	0.1	0.0	4505	2225	390.60
	ROE-SN	0.0	8.6	38.4	29.9	10.6	8.8	2.8	0.6	0.2	0.0	648	255	1.00[b]
1981/82	OTHER	0.0	3.6	39.0	31.5	15.3	5.8	3.9	0.8	0.1	0.0	2369	1384	303.92
	ROE-SN	0.0	8.7	39.7	23.1	17.4	3.8	4.5	2.2	0.5	0.0	2096	1168	302.55
1982/83	OTHER	0.0	0.8	16.6	32.0	23.2	13.2	4.9	5.7	3.0	0.6	1910	1526	47.33
	ROE-SN	0.0	5.8	29.8	28.7	18.3	8.7	2.8	3.8	1.6	0.5	2126	975	22.47
1983/84	OTHER	0.0	16.2	30.0	21.9	18.5	8.3	3.3	0.9	0.5	0.4	1527	555	52.95
	ROE-SN	0.0	21.9	31.4	18.8	13.4	9.3	2.6	1.5	0.6	0.3	1406	790	43.55
1984/85	OTHER	0.0	33.4	37.1	18.7	6.7	2.8	0.9	0.4	0.1	0.0	1843	288	64.51
	ROE-SN	0.0	29.3	39.1	18.5	6.3	4.2	1.5	0.9	0.1	0.0	2155	693	12.24
1985/86	ROE-SN	0.0	20.8	59.2	13.8	4.1	1.3	0.7	0.1	0.1	0.0	1961	542	1.00[b]
1986/87	ROE-SN	0.0	27.6	35.8	28.0	6.4	1.4	0.6	0.2	0.0	0.1	1257	246	1.00[b]
	ROE-GN	0.0	0.0	3.6	41.4	31.4	14.3	6.1	2.5	0.6	0.2	643	926	261.76

FISHERY	Average weight at age (g) 1	2	3	4	5	6	7	8	9	10
REDUCTION	13.7	57.7	93.4	118.5	142.9	160.3	175.2	188.5	193.8	222.2
ROE-SN	0.0	59.5	87.2	113.4	136.2	161.6	172.8	192.7	201.4	211.9
ROE-GN	0.0	59.4	112.0	140.0	154.0	167.8	178.1	176.7	199.0	213.0
OTHER	15.2	55.8	88.9	112.6	135.2	159.1	168.9	181.5	197.1	210.4

[a]Age composition from published reports.
[b]No seine roe fishery in this season. Age composition from pre-fishery charter samples only.
[c]Includes catch from "other" fisheries
[d]Includes catch from seine roe fisheries
[e]Includes catch from gillnet fisheries

Appendix Table 1.6. Age composition and catch in numbers by fishery and season and weight at age averaged over all seasons for the southern west coast Vancouver Island stock assessment region.

Season	Fishery	Percent at age 1	2	3	4	5	6	7	8	9	10	Number aged	Sample weight	Catch (x 10^{-5})
1950/51	REDUCTION	0.1	13.1	38.1	40.6	6.4	1.3	0.3	0.0	0.0	0.0	3843	551	1630.59
1951/52	REDUCTION	0.1	5.3	65.5	20.1	7.9	0.8	0.2	0.0	0.0	0.0	1686	593	1105.57
1952/53	REDUCTION	0.1	8.9	55.7	32.8	2.0	0.5	0.0	0.0	0.0	0.0	2777	1417	2.36
1953/54	REDUCTION	0.0	2.8	64.3	26.5	5.5	0.6	0.1	0.1	0.0	0.0	5730	2473	3086.25
1954/55	REDUCTION	0.0	16.8	59.4	19.7	3.4	0.6	0.0	0.0	0.0	0.0	2510	699	706.20
1955/56	REDUCTION	0.0	12.4	64.3	16.0	6.1	1.1	0.2	0.0	0.0	0.0	4653	2257	1931.15
1956/57	REDUCTION	0.0	2.7	71.9	24.8	0.3	0.2	0.0	0.0	0.0	0.0	588	497	312.93
1957/58	REDUCTION	0.0	15.6	55.3	25.0	4.0	0.1	0.0	0.0	0.0	0.0	707	432	68.62
1958/59	REDUCTION	0.0	6.4	61.0	25.1	6.0	1.0	0.1	0.2	0.1	0.0	2066	1383	4315.70
1959/60	REDUCTION	0.0	26.9	48.2	19.7	4.1	0.6	0.4	0.2	0.0	0.0	539	189	1988.85
1960/61	REDUCTION	0.0	52.7	33.9	10.0	3.1	0.2	0.0	0.0	0.0	0.0	419	54	1719.68
1961/62	REDUCTION	0.0	5.1	78.2	12.1	3.7	0.9	0.0	0.0	0.0	0.0	751	386	1659.51
1962/63	REDUCTION	0.0	3.5	44.4	45.5	5.6	0.8	0.2	0.0	0.0	0.0	886	316	404.28
1963/64	REDUCTION	0.0	2.6	60.8	25.5	10.1	0.8	0.3	0.0	0.0	0.0	1134	1003	1989.83
1964/65	REDUCTION	0.0	2.3	34.7	49.3	9.8	3.5	0.4	0.0	0.0	0.0	775	344	1141.93
1965/66	REDUCTION	0.0	0.3	41.3	33.3	21.3	2.7	1.0	0.0	0.0	0.0	300	403	636.21
1966/67	REDUCTION	2.4	20.7	55.5	16.7	3.4	0.8	0.3	0.2	0.0	0.0	0[a]	25	859.81
1971/72	ROE-SN	0.0	4.1	19.9	50.8	20.0	3.3	1.1	0.8	0.0	0.0	1222	843	319.50
1972/73	ROE-SN	0.0	0.9	32.3	24.1	31.0	10.1	1.3	0.3	0.1	0.0	1967	1330	678.19
	ROE-GN	0.0	0.0	7.9	22.9	51.8	13.5	2.9	1.0	0.2	0.0	624	526	63.80
1973/74	ROE-SN	0.0	12.1	45.1	25.7	11.0	5.0	1.0	0.1	0.0	0.0	3022	1434	341.88
	ROE-GN	0.0	0.0	26.1	30.7	26.1	13.6	3.4	0.0	0.0	0.0	176	30	207.72
1974/75	ROE-SN	0.0	0.7	46.5	21.9	14.2	9.4	5.7	1.4	0.2	0.0	6191	3025	901.22[c]
	ROE-GN	0.0	0.0	3.0	30.5	37.9	21.2	7.1	0.4	0.0	0.0	269	145	407.98
1975/76	ROE-SN	0.0	0.1	7.6	45.5	20.8	14.4	8.3	2.8	0.5	0.0	7026	1218	1358.83
	ROE-GN	0.0	0.0	0.7	41.8	33.6	15.3	5.9	2.3	0.3	0.1	1238	125	932.28
1976/77	ROE-SN	0.0	0.5	11.8	32.1	37.5	12.5	4.1	1.5	0.2	0.0	6171	1298	1226.50[c]
	ROE-GN	0.0	1.0	6.1	23.0	45.4	16.8	6.1	1.5	0.0	0.0	196	26	669.58
1977/78	OTHER	0.0	1.3	41.9	26.2	13.7	13.5	2.0	0.9	0.3	0.3	1727	416	183.29
	ROE-SN	0.0	0.5	35.1	18.7	18.6	20.8	4.8	1.3	0.2	0.1	5067	2353	381.15
	ROE-GN	0.0	0.0	1.2	5.3	20.1	49.6	17.3	5.8	0.5	0.2	417	84	730.95
1978/79	ROE-SN	0.0	0.5	9.9	39.2	18.5	16.4	11.9	2.6	0.8	0.2	2165	1149	411.88[c]
	ROE-GN	0.0	0.0	1.0	25.1	27.2	26.3	18.0	2.1	0.4	0.0	518	214	263.70
1979/80	ROE-SN	0.0	3.5	45.0	11.4	18.2	9.2	8.4	3.5	0.7	0.1	2037	1241	146.54[c]
	ROE-GN	0.0	0.0	0.0	4.4	40.7	25.6	16.8	11.4	0.8	0.3	386	717	36.65
1980/81	ROE-SN	0.0	4.0	37.7	26.4	10.6	11.5	6.4	2.8	0.6	0.0	3162	1247	251.13[c]
	ROE-GN	0.0	0.0	1.8	21.0	14.9	36.3	18.9	7.1	0.0	0.0	281	81	136.27
1981/82	ROE-SN	0.0	4.0	24.8	28.7	23.5	5.3	8.5	3.1	1.7	0.4	3930	2036	201.06[c]
	ROE-GN	0.0	0.0	0.3	17.3	39.5	11.4	23.3	5.4	2.6	0.3	352	216	49.47
1982/83	ROE-SN	0.0	4.5	23.3	22.8	21.7	16.2	4.0	5.3	1.2	1.1	2761	1911	476.41

Appendix Table 1.6 (cont'd).

Season	Fishery	Percent at age 1	2	3	4	5	6	7	8	9	10	Number aged	Sample weight	Catch (x 10^{-5})
1983/84	ROE-SN	0.0	20.5	36.8	14.1	9.6	10.5	6.1	1.1	1.1	0.2	2903	1266	485.38
1984/85	ROE-SN	0.0	21.1	50.2	16.1	4.1	2.9	3.4	1.8	0.1	0.3	2341	603	15.98[c]
1985/86	ROE-SN	0.0	4.2	48.8	27.2	10.3	3.9	2.7	2.1	0.7	0.1	3127	1073	1.00[b]
1986/87	ROE-SN	0.0	15.1	16.0	35.7	19.0	8.1	2.9	1.6	1.2	0.4	4050	2121	987.46

FISHERY	Average weight at age (g) 1	2	3	4	5	6	7	8	9	10
REDUCTION	22.9	57.2	89.9	112.9	132.2	149.3	156.4	166.8	173.2	237.6
ROE-SN	21.0	63.6	93.4	124.0	149.2	170.1	184.0	194.2	204.0	206.2
ROE-GN	0.0	45.5	104.3	135.4	154.0	168.4	179.4	184.5	184.6	188.5
OTHER	22.6	60.1	91.7	118.8	140.7	159.4	170.3	187.5	196.2	206.2

[a]Age composition from published reports.
[b]No seine roe fishery in this season. Age composition from pre-fishery charter samples only.
[c]Includes catch from "other" fisheries
[d]Includes catch from seine roe fisheries
[e]Includes catch from gillnet fisheries

Appendix Table 1.7 (cont'd).

Season	Fishery	Percent at age 1	2	3	4	5	6	7	8	9	10	Number aged	Sample weight	Catch (x 10^{-5})
1985/86	ROE-SN	0.0	2.4	47.2	44.1	2.5	1.1	1.2	0.9	0.6	0.0	1389	85	1.00[b]
1986/87	ROE-SN	0.0	14.1	22.6	23.1	36.4	2.1	0.3	0.5	0.4	0.4	940	289	1.00[b]
	ROE-GN	0.0	0.0	1.8	24.5	61.8	5.5	2.2	2.9	0.9	0.4	550	408	142.95

FISHERY	Average weight at age (g) 1	2	3	4	5	6	7	8	9	10
REDUCTION	9.8	57.3	89.2	111.2	131.7	145.4	157.3	175.4	190.2	156.6
ROE-SN	0.0	60.9	91.0	119.3	142.9	163.9	175.9	185.5	197.0	203.9
ROE-GN	0.0	0.0	117.2	131.7	147.3	156.9	162.4	170.3	163.7	182.0
OTHER	9.8	59.4	90.3	115.8	137.5	154.7	167.7	181.2	193.8	190.4

[a]Age composition from published reports.
[b]No seine roe fishery in this season. Age composition from pre-fishery charter samples only.
[c]includes catch from "other" fisheries
[d]includes catch from seine roe fisheries
[e]includes catch from gillnet fisheries

Appendix Table 1.7. Age composition and catch in numbers by fishery and season and weight at age averaged over all seasons for the northern west coast Vancouver Island stock assessment region.

Season	Fishery	Percent at age										Number aged	Sample weight	Catch ($\times 10^{-5}$)
		1	2	3	4	5	6	7	8	9	10			
1950/51	REDUCTION	0.0	1.5	27.0	54.1	12.8	3.6	1.0	0.0	0.0	0.0	196	190	566.14
1951/52	REDUCTION	0.0	0.2	10.2	27.5	52.2	7.1	2.1	0.5	0.1	0.0	3236	3206	1266.30
1953/54	REDUCTION	0.0	0.0	45.8	42.6	8.8	2.0	0.8	0.0	0.0	0.0	712	96	960.00
1954/55	REDUCTION	0.0	6.7	34.5	50.1	6.7	1.6	0.3	0.1	0.0	0.0	1486	558	628.76
1955/56	REDUCTION	0.0	10.0	58.1	9.5	19.0	2.6	0.5	0.2	0.1	0.0	0[a]	25	52.03
1956/57	REDUCTION	0.0	0.0	51.5	28.9	15.5	4.1	0.0	0.0	0.0	0.0	97	81	48.52
1957/58	REDUCTION	0.0	9.1	38.9	30.0	9.7	6.8	4.1	1.0	0.2	0.0	483	80	4.98
1958/59	REDUCTION	0.0	1.4	24.4	30.3	25.3	7.6	5.3	4.3	1.2	0.3	1599	1014	3194.28
1959/60	REDUCTION	0.0	5.0	56.8	23.8	9.6	3.2	1.0	0.4	0.2	0.1	2435	2242	3941.18
1960/61	REDUCTION	0.0	19.3	42.4	31.9	6.1	0.3	0.0	0.0	0.0	0.0	295	82	1840.47
1961/62	REDUCTION	0.0	7.1	78.7	9.4	3.1	1.1	0.6	0.0	0.0	0.0	1090	574	1362.97
1962/63	REDUCTION	0.0	0.5	47.3	47.4	3.7	0.9	0.1	0.0	0.0	0.0	1718	553	1658.16
1963/64	REDUCTION	0.0	1.0	53.8	28.2	15.9	1.0	0.0	0.0	0.0	0.0	195	239	182.93
1964/65	REDUCTION	0.0	0.9	22.2	43.6	26.5	4.7	0.4	0.9	0.9	0.0	234	93	352.62
1965/66	REDUCTION	0.0	13.6	26.8	26.1	23.2	9.1	1.2	0.0	0.0	0.0	0[a]	25	307.10
1966/67	REDUCTION	0.0	4.7	63.6	23.9	6.1	1.5	0.1	0.1	0.0	0.0	0[a]	25	506.07
1971/72	ROE-SN	0.0	0.3	13.8	38.7	40.7	4.3	1.4	0.6	0.3	0.0	349	99	177.82
1972/73	ROE-SN	0.0	0.2	24.5	24.8	35.0	13.0	2.3	0.2	0.2	0.0	609	358	557.43[e]
1973/74	ROE-SN	0.0	3.0	40.4	21.7	16.9	13.8	3.7	0.4	0.1	0.0	2398	2045	862.72[e]
1974/75	ROE-SN	0.0	0.5	66.3	16.3	6.6	5.4	3.7	1.1	0.1	0.0	4185	2248	685.51[ce]
1975/76	ROE-SN	0.0	0.5	12.8	51.5	16.7	8.2	7.5	2.5	0.3	0.0	2204	492	259.12
	ROE-GN	0.0	0.0	2.7	33.8	30.4	18.6	9.9	4.6	0.0	0.0	263	24	139.02
1976/77	ROE-SN	0.0	0.9	19.5	20.3	33.9	11.3	8.9	3.7	1.6	0.0	575	1613	52.30
	ROE-GN	0.0	0.0	0.0	8.6	39.5	18.5	19.8	9.9	3.1	0.6	162	92	180.00
1977/78	OTHER	0.0	1.3	49.6	15.0	14.4	16.3	2.6	0.6	0.3	0.0	701	259	81.77
	ROE-SN	0.0	1.7	69.0	13.3	6.4	5.8	2.2	1.5	0.1	0.1	896	650	78.36
	ROE-GN	0.0	0.0	1.1	2.7	21.8	41.0	23.4	8.5	1.1	0.5	188	65	209.21
1978/79	ROE-SN	0.0	1.2	18.1	65.2	9.1	3.3	2.7	0.3	0.1	0.1	1800	724	495.07
	ROE-GN	0.0	0.0	2.0	43.5	18.4	17.7	17.7	0.7	0.0	0.0	147	126	299.06
1979/80	ROE-SN	0.0	1.6	41.5	22.5	30.1	3.2	1.0	0.1	0.0	0.0	966	84	1.00[b]
	ROE-GN	0.0	0.0	2.1	9.9	77.3	8.5	1.4	0.7	0.0	0.0	141	123	159.85
1980/81	ROE-SN	0.0	1.3	15.2	54.5	10.5	16.5	1.9	0.1	0.0	0.0	1346	386	185.26
	ROE-GN	0.0	0.0	0.0	98.1	1.9	0.0	0.0	0.0	0.0	0.0	53	53	154.75
1981/82	ROE-SN	0.0	0.5	27.8	17.5	38.2	5.0	9.9	0.9	0.2	0.0	2173	499	21.25
	ROE-GN	0.0	0.0	0.8	7.9	47.6	11.5	29.0	3.1	0.2	0.0	620	564	197.84
1982/83	ROE-SN	0.0	2.8	18.3	19.1	20.9	27.2	5.7	5.9	0.2	0.0	545	132	1.00[b]
	ROE-GN	0.0	0.0	0.3	13.5	22.7	47.0	6.0	10.0	0.3	0.2	651	191	188.25
1983/84	ROE-SN	0.0	42.0	44.9	4.5	1.1	2.3	3.4	0.6	1.1	0.0	176	369	0.29[c]
	ROE-GN	0.0	0.0	1.0	5.6	28.1	25.9	32.5	4.2	2.4	0.2	1027	626	66.55
1984/85	ROE-SN	0.0	18.2	65.7	7.5	2.4	2.3	2.4	1.2	0.2	0.0	654	215	1.00[b]

Appendix Table 2.1. Estimates of numbers at age, spawn, and other parameters from age-structured model analysis for the Queen Charlotte Islands stock assessment region.

Season	Estimated numbers at age (x 10^{-5}) for period one										Spawn Index	Estimated Spawn	Spawning Biomass (t)
	1	2	3	4	5	6	7	8	9	10			
1950/51	6377	2752	1714	1029	208	139	0	0	0	59	171	142	4465
1951/52	32536	4066	1755	1055	526	95	61	0	0	26	112	115	4377
1952/53	4035	20745	2449	936	400	140	22	14	0	6	262	529	19113
1953/54	5331	2573	13227	1562	597	255	89	14	9	4	486	416	12210
1954/55	1765	3399	1635	8376	935	347	147	51	8	7	247	1217	42276
1955/56	2680	1125	2162	1035	5269	585	217	92	32	9	370	192	7890
1956/57	6455	1709	710	634	301	733	51	19	8	4	63	36	1554
1957/58	2207	4116	752	70	171	33	40	3	1	1	37	65	2355
1958/59	5105	1407	1310	219	22	29	4	5	0	0	351	207	7685
1959/60	6237	3255	615	573	112	10	13	2	2	0	129	147	4995
1960/61	11868	3977	2076	392	365	71	6	8	1	2	316	186	7668
1961/62	2648	7567	2533	1300	240	220	43	4	5	2	206	200	9365
1962/63	6855	1688	4809	1417	624	99	85	17	1	3	213	235	11174
1963/64	703	4371	1073	2549	613	214	31	27	5	1	116	67	2972
1964/65	521	448	2770	406	741	85	19	3	2	1	59	33	1751
1965/66	388	332	232	115	106	72	4	1	0	0	133	47	2579
1966/67	373	247	176	84	53	41	26	1	0	0	22	45	2540
1967/68	786	238	158	108	51	32	25	16	1	0	33	60	3329
1968/69	2531	501	150	98	68	32	20	15	10	1	53	52	2874
1969/70	1715	1614	320	96	63	43	20	13	10	7	79	73	3976
1970/71	4029	1093	1029	204	61	40	27	13	8	10	107	117	6535
1971/72	10545	2569	697	656	130	39	25	18	8	12	125	139	8390
1972/73	14012	6723	1634	412	384	73	22	14	10	11	123	150	8738
1973/74	3406	8934	4287	987	230	201	37	11	7	11	416	340	17691
1974/75	3695	2172	5696	2617	585	131	112	21	6	10	209	477	22814
1975/76	4295	2356	1384	3512	1501	317	69	60	11	9	457	557	27142
1976/77	1630	2738	1501	863	1881	737	151	33	28	9	590	512	25734
1977/78	38842	1039	1746	839	455	901	341	70	15	18	496	360	18235
1978/79	2508	24766	662	952	422	202	382	145	30	14	407	212	11194
1979/80	1113	1599	15770	405	473	163	67	133	50	15	963	888	42303

Appendix Table 2.1 (cont'd).

Season	Estimated numbers at age (x 10^{-5}) for period one										Spawn Index	Estimated Spawn	Spawning Biomass (t)
	1	2	3	4	5	6	7	8	9	10			
1980/81	1170	710	1019	9932	249	270	89	37	74	36	981	1086	49371
1981/82	7700	746	452	640	5964	139	145	48	20	60	870	1167	49044
1982/83	3405	4910	475	282	394	3560	82	85	29	47	628	829	39318
1983/84	668	2171	3118	288	168	224	1986	46	48	43	695	666	31204
1984/85	937	426	1377	1871	169	94	123	1094	25	50	603	470	24508
1985/86	461	597	267	832	1065	87	46	61	543	37	209	390	21141
1986/87	295	294	381	166	489	588	47	25	33	313	543	311	16240
	Estimated availability at age (λj)												
	0.00	0.11	0.46	0.63	0.91	1.00	1.00	1.00	1.00	1.00			
	Estimated relative selectivity at age for gillnet gear												
	0.00	0.00	0.01	0.23	0.72	1.00	0.84	0.84	0.84	0.84			

The coefficients for the Ricker stock-recruitment curve are: alpha = 36.70, beta = 0.2631E-02. The estimated spawn index-escapement conversion factor is 0.955E-02.

Appendix Table 2.2. Estimates of numbers at age, spawn, and other parameters from age-structured model analysis for the Prince Rupert District stock assessment region.

Season	Estimated numbers at age (x 10^{-5}) for period one										Spawn Index	Estimated Spawn	Spawning Biomass (t)
	1	2	3	4	5	6	7	8	9	10			
1950/51	8646	5336	6302	7947	1099	404	0	0	0	214	1058	511	11761
1951/52	18864	5512	3246	3362	3030	279	68	0	0	36	641	177	4739
1952/53	5599	12027	3367	1796	1110	538	21	5	0	3	961	967	26053
1953/54	14979	3570	7667	2095	1112	677	325	12	3	2	835	306	8042
1954/55	5012	9550	2234	4319	797	281	112	54	2	1	869	447	11104
1955/56	9424	3196	6053	1360	1901	273	77	31	15	1	951	1400	34639
1956/57	18844	6009	1943	3315	776	1022	140	40	16	8	1279	479	11914
1957/58	6180	12014	3580	846	1368	234	230	32	9	5	507	1108	26931
1958/59	33584	3940	7457	2152	501	778	129	127	18	8	1285	1191	33208
1959/60	16323	21414	2487	4299	1224	268	398	66	65	13	1087	1298	29523
1960/61	9149	10407	12732	1468	2247	570	114	170	28	33	990	1124	29112
1961/62	27079	5833	6279	5989	666	813	171	34	51	18	1530	1105	31297
1962/63	3779	17265	3661	3423	2981	285	310	65	13	26	783	1030	24874
1963/64	1660	2410	9582	1851	1520	1037	81	88	18	11	1185	1518	37870
1964/65	2024	1059	1435	4348	936	669	410	32	35	12	501	368	10635
1965/66	2973	1291	501	536	1640	232	107	66	5	7	332	262	6928
1966/67	3994	1895	823	274	228	525	58	27	16	3	222	253	6565
1967/68	19002	2546	833	278	121	78	145	16	7	5	433	348	9209
1968/69	13549	12116	1544	444	161	67	42	77	9	7	74	230	6202
1969/70	6517	8639	7715	970	270	96	39	24	45	9	886	895	24604
1970/71	12339	4155	5482	4830	603	166	58	24	15	33	716	1325	32066
1971/72	10805	7868	2632	3368	2943	359	97	34	14	28	1000	1358	45525
1972/73	5117	6889	5017	1664	2047	1745	209	57	20	24	730	1843	61310
1973/74	3449	3263	4392	3159	1045	1276	1083	130	35	27	670	1685	54544
1974/75	5602	2199	2080	2771	1958	626	741	638	76	37	814	1707	49230
1975/76	3328	3572	1400	1315	1734	1214	385	457	393	70	1158	1431	48591
1976/77	3378	2122	2278	884	804	1034	710	226	268	272	1438	1118	37325
1977/78	29369	2154	1352	1379	517	436	529	370	118	281	750	772	25468
1978/79	5505	18726	1369	827	794	260	194	249	174	188	814	662	22045
1979/80	5667	3510	11936	846	493	438	134	103	133	193	1529	1267	38096

Appendix Table 2.2 (cont'd).

Season	Estimated numbers at age (x 10^{-5}) for period one										Spawn Index	Estimated Spawn	Spawning Biomass (t)
	1	2	3	4	5	6	7	8	9	10			
1980/81	6794	3614	2236	7456	519	286	242	76	58	184	1175	1512	38679
1981/82	21985	4332	2303	1406	4599	312	168	143	45	144	1305	1827	41317
1982/83	3746	14018	2760	1449	882	2860	193	104	88	117	1826	1836	47915
1983/84	4733	2389	8938	1759	924	562	1823	123	66	131	2032	1775	43737
1984/85	16100	3018	1521	5635	1090	547	319	1059	71	114	2056	1700	41820
1985/86	1033	10266	1922	948	3422	608	282	172	571	100	2084	1518	43544
1986/87	65	659	6541	1190	574	1882	306	149	91	355	2555	1544	43026
	Estimated availability at age (λj)												
	0.00	0.09	0.38	0.55	0.82	1.00	1.00	1.00	1.00	1.00			
	Estimated relative selectivity at age for gillnet gear												
	0.00	0.02	0.01	0.17	0.69	1.00	0.70	0.70	0.70	0.70			

The coefficients for the Ricker stock-recruitment curve are: alpha = 39.98, beta = 0.1463E-02. The estimated spawn index-escapement conversion factor is 0.154E-01.

Appendix Table 2.3. Estimates of numbers at age, spawn, and other parameters from age-structured model analysis for the Central Coast stock assessment region.

Season	Estimated numbers at age (x 10^{-5}) for period one										Spawn Index	Estimated Spawn	Spawning Biomass (t)
	1	2	3	4	5	6	7	8	9	10			
1950/51	6097	2350	3782	4660	822	329	0	0	81	3	834	531	13342
1951/52	32660	3885	1428	1588	1524	180	64	0	0	16	343	143	3561
1952/53	3508	20808	2368	488	397	175	15	5	0	1	629	379	9149
1953/54	3565	2237	13262	1494	298	238	104	9	3	1	487	367	7709
1954/55	8268	2271	1382	6664	473	61	43	19	2	1	542	1239	26737
1955/56	12878	5271	1411	816	3495	229	29	20	9	1	369	326	7646
1956/57	14048	8205	2893	511	226	528	28	4	2	1	213	131	3140
1957/58	2971	8950	4903	854	134	29	53	3	0	0	367	625	13572
1958/59	5510	1894	5445	2444	405	56	12	21	1	0	352	244	5465
1959/60	17367	3511	1116	2286	700	66	8	2	3	0	681	1230	23767
1960/61	9255	11073	2028	632	1343	399	38	4	1	2	314	394	8745
1961/62	8992	5898	6706	721	219	330	89	8	1	1	860	506	12682
1962/63	4583	5732	3691	3889	349	94	138	37	3	1	374	220	5275
1963/64	4780	2920	3645	1567	1039	48	10	15	4	0	430	282	7130
1964/65	9268	3046	1588	1193	461	182	7	2	2	1	171	247	7160
1965/66	4096	5906	1865	650	425	119	43	2	0	1	158	134	3479
1966/67	1801	2610	1435	271	155	42	8	3	0	0	322	232	6164
1967/68	7390	1147	627	278	88	34	8	2	1	0	370	269	7537
1968/69	6037	4712	684	347	161	49	19	5	1	0	162	213	5955
1969/70	7933	3849	3002	434	218	101	31	12	3	1	637	492	13677
1970/71	13390	5058	2442	1904	273	137	63	19	7	2	289	774	22019
1971/72	9152	8537	3190	1463	1114	155	77	35	11	5	435	691	18667
1972/73	12075	5834	5415	1842	737	507	68	34	16	7	961	1131	34211
1973/74	5987	7698	3714	3185	1032	379	249	34	17	11	890	1128	30526
1974/75	3681	3817	4901	2317	1806	491	159	103	14	12	784	1452	39382
1975/76	4338	2347	2432	3028	1345	911	224	72	47	11	1426	1243	31478
1976/77	3191	2766	1485	1494	1670	628	380	92	30	24	1187	1101	30377
1977/78	30124	2034	1761	883	840	790	262	157	38	22	732	649	17644
1978/79	5339	19205	1296	1025	455	309	226	74	44	17	694	1150	27095
1979/80	5158	3404	12246	827	654	290	197	144	47	39	1159	1802	45978

Appendix Table 2.3 (cont'd).

Season	Estimated numbers at age (x 10^{-5}) for period one										Spawn Index	Estimated Spawn	Spawning Biomass (t)
	1	2	3	4	5	6	7	8	9	10			
1980/81	2163	3289	2170	7805	524	409	180	122	89	53	1317	2232	51971
1981/82	1736	1379	2097	1380	4910	321	245	107	73	85	1302	2210	54359
1982/83	6450	1107	876	1307	840	2809	176	134	59	86	1600	1618	40111
1983/84	2256	4112	705	547	793	481	1544	96	73	79	1075	1042	24662
1984/85	2851	1438	2610	429	313	410	233	745	46	74	1155	858	24539
1985/86	1195	1818	911	1579	249	166	204	116	370	60	1262	766	21828
1986/87	112	762	1154	560	945	141	90	111	63	233	1138	691	19954
	Estimated availability at age (λj)												
	0.00	0.14	0.50	0.70	0.94	1.00	1.00	1.00	1.00	1.00			
	Estimated relative selectivity at age for gillnet gear												
	0.00	0.00	0.03	0.24	0.65	0.97	1.00	1.00	1.00	1.00			

The coefficients for the Ricker stock-recruitment curve are: alpha = 38.64, beta = 0.1613E-02. The estimated spawn index-escapement conversion factor is 0.168E-01.

Appendix Table 2.4. Estimates of numbers at age, spawn, and other parameters from age-structured model analysis for the Northern Strait of Georgia stock assessment region.

Season	Estimated numbers at age (x 10^{-5}) for period one										Spawn Index	Estimated Spawn	Spawning Biomass (t)
	1	2	3	4	5	6	7	8	9	10			
1950/51	8796	5451	2865	1383	325	65	0	0	0	26	2789	1258	9115
1951/52	18821	5606	3429	1211	388	84	17	0	0	7	2903	1976	14699
1952/53	10862	11996	3387	1429	417	127	28	6	0	2	3259	3707	23376
1953/54	4664	6925	7594	1948	799	231	71	15	3	1	1809	2215	14598
1954/55	4436	2973	4382	4339	651	253	73	22	5	1	2420	5197	33552
1955/56	6094	2827	1776	1906	1778	258	100	29	9	2	1231	2362	15451
1956/57	16273	3884	1617	815	563	490	71	28	8	3	1381	1076	7783
1957/58	8955	10370	2464	513	196	122	106	15	6	2	735	755	5266
1958/59	5545	5708	6569	1270	153	55	34	30	4	2	2039	1846	12983
1959/60	12354	3534	3118	2259	303	33	12	7	6	1	1871	2196	15298
1960/61	12574	7874	1990	1285	732	93	10	4	2	2	1460	1530	9549
1961/62	14114	8014	4730	945	393	210	27	3	1	1	1445	1757	12545
1962/63	6711	8995	4764	1377	234	89	47	6	1	1	1197	914	5762
1963/64	3284	4276	5053	1446	209	29	11	6	1	0	1279	962	7738
1964/65	2603	2093	2567	1430	240	29	4	2	1	0	1343	1412	11843
1965/66	1665	1659	1056	591	361	55	7	1	0	0	258	231	2030
1966/67	1073	1061	775	159	61	26	4	0	0	0	497	346	2873
1967/68	3574	684	248	130	31	10	4	1	0	0	551	348	3044
1968/69	3774	2279	414	124	66	15	5	2	0	0	815	714	5581
1969/70	3076	2406	1429	256	75	40	9	3	1	0	2437	1758	15607
1970/71	4488	1961	1523	888	159	47	25	6	2	1	2299	1982	17007
1971/72	6906	2862	1242	943	544	97	28	15	4	2	1519	1454	10833
1972/73	9392	4402	1815	641	397	222	40	12	6	2	1358	1213	9884
1973/74	6429	5987	2802	1047	281	149	73	13	4	3	2838	2313	17420
1974/75	11145	4099	3817	1778	593	126	53	25	4	2	3760	4785	34125
1975/76	9020	7107	2610	2354	1000	272	47	19	9	2	3734	3891	26273
1976/77	4314	5751	4519	1633	1289	440	96	16	7	4	5592	5348	39709
1977/78	7423	2750	3654	2653	864	553	153	33	6	4	4538	4500	31480
1978/79	5712	4732	1746	2100	1313	350	185	50	11	3	4511	3986	29701
1979/80	5333	3642	3016	1087	1169	605	134	69	19	5	4394	4949	33571

Appendix Table 2.4 (cont'd).

Season	Estimated numbers at age (x 10^{-5}) for period one										Spawn Index	Estimated Spawn	Spawning Biomass (t)
	1	2	3	4	5	6	7	8	9	10			
1980/81	5225	3400	2318	1865	645	639	304	67	34	12	3007	4908	34520
1981/82	4373	3332	2154	1389	1059	322	282	132	29	20	4869	4304	29547
1982/83	7312	2788	2124	1363	820	539	142	121	57	21	2828	2601	18545
1983/84	10879	4662	1748	1118	574	238	110	27	23	15	2202	2224	15754
1984/85	7323	6936	2955	951	502	173	48	21	5	7	1970	3148	22902
1985/86	4723	4669	4361	1737	489	201	54	15	6	4	4074	5464	40075
1986/87	1425	3011	2977	2780	1107	312	128	35	9	7	3588	5664	38189
	Estimated availability at age (λj)												
	0.00	0.13	0.70	0.95	1.00	1.00	1.00	1.00	1.00	1.00			
	Estimated relative selectivity at age for gillnet gear												
	0.00	0.00	0.02	0.20	0.57	0.95	1.00	1.00	1.00	1.00			

The coefficients for the Ricker stock-recruitment curve are: alpha = 8.623, beta = 0.3982E-03. The estimated spawn index-escapement conversion factor is 0.603E-01

Appendix Table 2.5. Estimates of numbers at age, spawn, and other parameters from age-structured model analysis for the Southern Strait of Georgia stock assessment region.

Season	Estimated numbers at age (x 10^{-5}) for period one										Spawn Index	Estimated Spawn	Spawning Biomass (t)
	1	2	3	4	5	6	7	8	9	10			
1950/51	11907	5619	3614	1124	230	46	0	1	8	0	285	733	8617
1951/52	18942	7588	3488	981	229	45	9	0	0	2	768	389	4479
1952/53	14497	12071	4635	944	125	27	5	1	0	0	2489	1582	15807
1953/54	11889	9243	7682	2699	504	67	14	3	1	0	1774	1192	13336
1954/55	10813	7577	5869	2790	499	88	12	2	0	0	1380	1724	20311
1955/56	5226	6892	4727	1999	713	123	22	3	1	0	890	761	8227
1956/57	13526	3331	4240	1153	279	91	16	3	0	0	409	381	4230
1957/58	13004	8619	2073	538	111	23	8	1	0	0	895	530	5596
1958/59	6569	8288	5376	644	137	27	6	2	0	0	1074	970	10412
1959/60	16008	4187	5031	2473	195	40	8	2	1	0	504	879	10488
1960/61	12494	10202	2518	1315	400	29	6	1	0	0	602	572	6281
1961/62	9449	7962	5585	832	200	56	4	1	0	0	324	437	5188
1962/63	5499	6021	4935	1525	99	21	6	0	0	0	489	448	5077
1963/64	3784	3504	3427	1616	180	10	2	1	0	0	513	310	3917
1964/65	3601	2411	2063	616	143	14	1	0	0	0	151	201	2591
1965/66	2358	2295	1304	485	65	13	1	0	0	0	193	163	2049
1966/67	639	1503	1134	473	61	7	2	0	0	0	138	128	1553
1967/68	1156	407	118	66	34	4	0	0	0	0	230	136	1557
1968/69	1387	737	142	39	22	11	1	0	0	0	346	197	2305
1969/70	1140	885	442	78	21	12	6	1	0	0	576	364	4647
1970/71	1513	727	554	266	47	13	7	4	0	0	491	304	3804
1971/72	2483	964	458	336	148	26	7	4	2	0	465	404	4864
1972/73	3358	1583	592	240	156	65	11	3	2	1	455	548	6723
1973/74	2464	2141	1009	364	137	79	29	5	2	1	699	952	11554
1974/75	5059	1571	1361	624	217	77	41	16	3	2	704	1113	13389
1975/76	3893	3226	1002	862	373	117	37	22	8	2	541	981	9606
1976/77	1849	2482	2045	596	442	176	51	17	10	5	315	1138	11883
1977/78	2087	1179	1566	1121	283	197	74	22	8	7	696	1007	10564
1978/79	1899	1331	744	776	442	102	65	26	8	5	1492	485	5124
1979/80	1442	1210	835	343	205	113	26	17	7	3	746	745	8078

Appendix Table 2.5 (cont'd).

Season	Estimated numbers at age (x 10^{-5}) for period one										Spawn Index	Estimated Spawn	Spawning Biomass (t)
	1	2	3	4	5	6	7	8	9	10			
1980/81	650	919	770	492	197	117	65	15	10	6	551	607	6580
1981/82	915	414	573	388	212	84	50	28	6	7	206	337	3873
1982/83	1449	583	232	154	101	53	21	13	7	3	419	254	2811
1983/84	2717	924	370	135	79	51	27	11	6	5	466	296	3653
1984/85	2301	1732	573	210	68	40	26	14	5	6	465	552	6564
1985/86	5513	1467	1085	341	123	40	23	15	8	7	476	1048	12596
1986/87	263	3515	935	692	217	78	25	15	10	9	604	953	10545
	Estimated availability at age (λj)												
	0.00	0.15	0.72	0.98	1.00	1.00	1.00	1.00	1.00	1.00			
	Estimated relative selectivity at age for gillnet gear												
	0.00	0.00	0.02	0.24	0.60	1.00	0.70	0.70	0.70	0.70			

The coefficients for the Ricker stock-recruitment curve are: alpha = 10.33, beta = 0.6350E-03. The estimated spawn index-escapement conversion factor is 0.393E-01.

Appendix Table 2.6. Estimates of numbers at age, spawn, and other parameters from age-structured model analysis for the Southern West Coast of Vancouver Island stock assessment region.

Season	Estimated numbers at age (x 10^{-5}) for period one										Spawn Index	Estimated Spawn	Spawning Biomass (t)
	1	2	3	4	5	6	7	8	9	10			
1950/51	4586	2800	1235	993	146	30	0	6	0	0	475	173	3334
1951/52	7703	2924	1621	307	159	21	4	0	1	0	387	106	2140
1952/53	3282	4911	1818	463	46	21	3	1	0	0	660	450	7951
1953/54	5416	2092	3131	1158	295	29	13	2	0	0	453	175	3356
1954/55	3816	3453	1266	446	119	24	2	1	0	0	602	390	7369
1955/56	6378	2433	2108	487	176	46	9	1	0	0	597	193	3729
1956/57	10245	4067	1365	373	77	24	6	1	0	0	424	416	7435
1957/58	4739	6533	2586	695	188	38	12	3	1	0	857	896	14342
1958/59	4213	3022	4157	1619	431	116	24	8	2	0	387	368	6612
1959/60	8544	2686	1715	652	224	51	14	3	1	0	449	349	6936
1960/61	4459	5447	1303	369	151	48	11	3	1	0	396	370	7288
1961/62	8049	2843	2820	375	101	39	12	3	1	0	671	378	7885
1962/63	3143	5132	1748	791	101	26	10	3	1	0	371	403	7628
1963/64	1931	2004	3261	977	362	46	12	4	1	0	915	444	9066
1964/65	2650	1231	1238	1152	246	86	11	3	1	0	652	327	7205
1965/66	1229	1690	764	481	309	63	22	3	1	0	239	242	5515
1966/67	1475	784	1076	285	148	91	18	6	1	0	117	155	3667
1967/68	6083	940	370	389	63	30	19	4	1	0	364	292	6897
1968/69	13471	3879	600	236	248	40	19	12	2	1	429	431	9909
1969/70	10651	8590	2473	382	150	158	26	12	8	2	959	958	23066
1970/71	14515	6792	5477	1577	244	96	101	16	8	6	1256	2004	51883
1971/72	14527	9255	4331	3492	1006	155	61	64	10	9	1107	2110	47640
1972/73	25797	9263	5889	2699	2053	589	91	36	38	11	471	2657	61192
1973/74	11074	16449	5901	3529	1498	1113	315	49	19	26	678	4359	88343
1974/75	5966	7061	10448	3610	2122	860	618	177	28	26	1229	4120	94105
1975/76	6513	3804	4496	6240	1999	1078	411	303	87	26	1426	2958	61575
1976/77	2003	4153	2424	2763	2954	766	354	144	107	40	1558	2160	44871
1977/78	4779	1277	2642	1403	1275	1142	261	128	52	53	1355	1770	33796
1978/79	3874	3047	811	1478	703	501	375	93	45	37	1291	1052	21614
1979/80	2402	2470	1941	475	732	302	194	152	38	34	1264	1199	23957

Appendix Table 2.6 (cont'd).

Season	Estimated numbers at age (x 10^{-5}) for period one										Spawn Index	Estimated Spawn	Spawning Biomass (t)
	1	2	3	4	5	6	7	8	9	10			
1980/81	2056	1532	1570	1175	282	423	172	111	87	41	1272	1166	23078
1981/82	3417	1311	967	903	647	141	199	83	54	62	821	965	18672
1982/83	4722	2179	828	567	507	349	74	106	44	61	534	642	13259
1983/84	5450	3011	1368	419	253	222	153	33	46	46	799	658	14887
1984/85	2043	3475	1822	696	197	117	103	71	15	43	844	1169	27552
1985/86	9566	1303	2212	1154	441	125	74	65	45	37	944	1361	31607
1986/87	786	6100	831	1410	736	281	79	47	42	52	1214	841	19120
	Estimated availability at age (λj)												
	0.00	0.09	0.73	0.96	1.00	1.00	1.00	1.00	1.00	1.00			
	Estimated relative selectivity at age for gillnet gear												
	0.00	0.00	0.03	0.23	0.66	1.00	0.85	0.85	0.85	0.85			

The coefficients for the Ricker stock-recruitment curve are: alpha = 16.93 ,beta =0.7200E-03
The estimated spawn index-escapement conversion factor is 0.227E-01.

Appendix Table 2.7. Estimates of numbers at age, spawn, and other parameters from age-structured model analysis for the Northern West Coast of Vancouver Island stock assessment region.

Season	Estimated numbers at age (x 10^{-5}) for period one										Spawn Index	Estimated Spawn	Spawning Biomass (t)
	1	2	3	4	5	6	7	8	9	10			
1950/51	3388	1082	1154	1995	289	85	0	0	0	24	792	899	15218
1951/52	8304	2160	683	617	1015	141	41	0	0	12	316	213	3753
1952/53	3448	5295	1376	339	135	159	21	6	0	2	1133	619	10105
1953/54	3631	2198	3376	877	216	86	101	14	4	1	839	404	6381
1954/55	7060	2315	1402	1796	307	66	26	31	4	2	724	963	17106
1955/56	7372	4502	1443	726	914	150	32	13	15	3	1098	1304	23043
1956/57	7650	4700	2867	904	456	573	94	20	8	11	1790	1531	25057
1957/58	8767	4878	2997	1808	569	286	360	59	13	12	625	1871	27207
1958/59	4166	5590	3110	1910	1151	362	182	229	38	16	529	492	7328
1959/60	9389	2657	3531	1403	416	179	55	27	34	8	253	243	4284
1960/61	4856	5987	1554	654	230	39	16	5	2	4	308	214	3824
1961/62	2786	3096	3525	336	142	36	6	2	1	1	639	491	9497
1962/63	1365	1776	1900	1422	120	45	11	2	1	1	449	274	4970
1963/64	1571	870	1126	618	343	22	8	2	0	0	612	640	11644
1964/65	2067	1002	553	642	356	194	12	5	1	0	809	448	9112
1965/66	860	1318	636	287	306	161	88	6	2	1	284	329	7237
1966/67	787	549	816	359	131	132	69	37	2	1	394	360	8303
1967/68	3279	502	325	318	152	52	52	27	15	1	272	342	7604
1968/69	6397	2091	320	207	203	97	33	33	17	10	485	368	8212
1969/70	4615	4079	1333	204	132	129	62	21	21	17	676	581	13616
1970/71	3827	2943	2601	850	130	84	83	39	13	25	495	1046	25203
1971/72	4434	2440	1876	1658	542	83	54	53	25	24	923	992	20621
1972/73	6567	2827	1555	1173	959	309	47	31	30	28	727	998	20303
1973/74	1754	4187	1802	859	572	446	143	22	14	27	301	847	16530
1974/75	1912	1118	2645	810	366	226	175	56	9	16	659	1136	22677
1975/76	8255	1219	710	1268	406	176	108	84	27	12	453	700	13188
1976/77	1754	5264	776	420	645	181	72	39	30	14	589	577	10194
1977/78	4681	1118	3356	484	235	308	76	25	14	16	1000	868	14547
1978/79	1431	2985	711	2043	254	97	103	20	7	8	1364	628	10324
1979/80	1017	912	1897	360	823	68	19	14	3	2	1516	807	13294

Appendix Table 2.7 (cont'd).

Season	Estimated numbers at age (x 10^{-5}) for period one										Spawn Index	Estimated Spawn	Spawning Biomass (t)
	1	2	3	4	5	6	7	8	9	10			
1980/81	383	649	582	1206	209	410	30	7	5	2	728	644	10799
1981/82	1387	244	411	342	622	92	158	10	2	2	909	527	8704
1982/83	8371	884	156	255	192	288	36	50	3	1	669	287	4916
1983/84	4907	5338	564	98	138	79	93	8	12	1	482	478	9034
1984/85	3710	3129	3403	358	58	71	36	36	3	5	296	751	15355
1985/86	18839	2365	1995	2169	228	37	45	23	23	5	741	1485	31072
1986/87	3983	12012	1508	1271	1383	145	23	29	14	18	1013	1598	34874
	Estimated availability at age (λj)												
	0.00	0.05	0.67	0.86	0.99	1.00	1.00	1.00	1.00	1.00			
	Estimated relative selectivity at age for gillnet gear												
	0.00	0.00	0.01	0.19	0.45	0.68	1.00	1.00	1.00	1.00			

The coefficients for the Ricker stock-recruitment curve are: alpha = 10.20, beta = 0.9191E-03. The estimated spawn index-escapement conversion factor is 0.248E-01.